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Temporal Variability of Toxic Contaminants in Animal Diets

(U.S.) Health Effects Research Lab.
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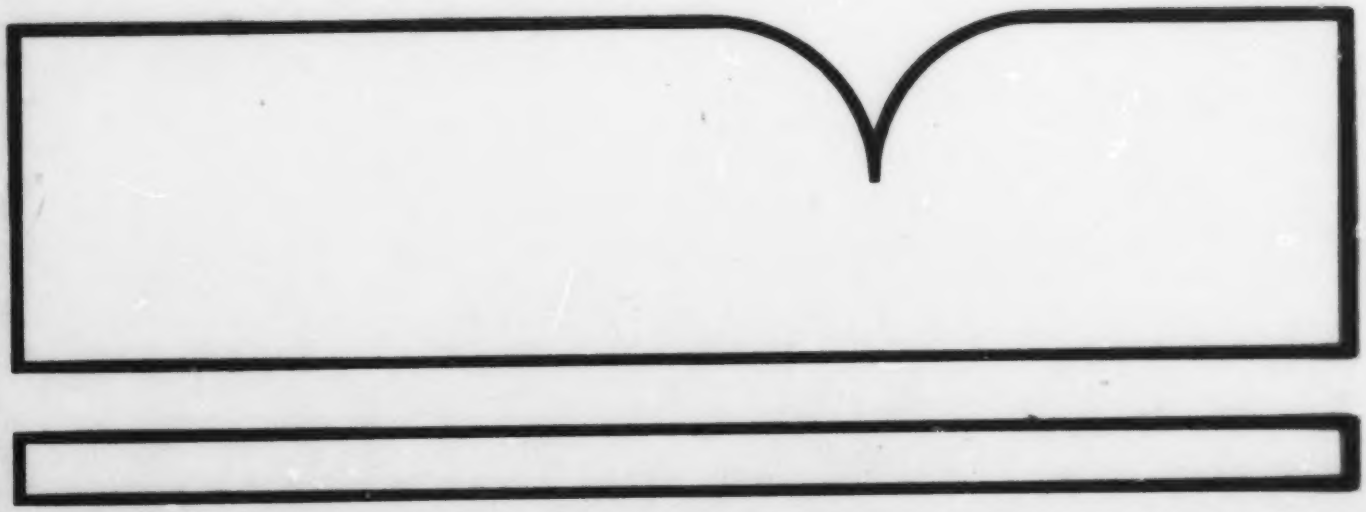

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TEMPORAL VARIABILITY OF TOXIC CONTAMINANTS IN ANIMAL DIETS

by

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Uncertified commercial research animal feed (Purina Chow™) was analyzed over forty--one months to determine essential and trace elements and toxic contaminants. Parametric statistics and graphic chronologic progressions of the results are presented for cat, monkey, rodent (rat/mouse), guinea pig and dog diets. Concentrations of toxic contaminants are discussed in terms of Maximum Allowable Concentrations (MAC) proposed by EPA. The impact of undesirable contaminants on in vivo animal studies is analyzed. Practical aspects of cost-effectiveness of feed analysis in a major research setting is discussed.

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FOREWORD

The U.S. Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our national environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involes defining the problem, measuring its impact, and searching for solutions. The primary mission of the Health Effects Research Laboratory in Cincinnati (HERL) is to provide a sound health effects data base in support of the regulatory activities of the EPA. To this end, HERL conducts a research program to identify, characterize, and quantitate harmful effects of pollutants that may result from exposure to chemical, physical, or biological information generated by these activities, new research techniques and methods are being developed that contribute to a better understanding of human biochemical and physiological functions, and how these functions are altered by low-level insults.

This report describes the results of a forty-one months study in which toxicological attributes of research animal feed have been analyzed. Since a major segment of health effects research activities involves laboratory animals of diverse species, nutritional and toxicological impact of animal diet on laboratory studies is of utmost concern during the validation of experimental findings. Understanding of the toxicological impact of animal feed contributes significantly both to the efficacy of research within the Agency, as well as to the rationale of regulatory action aimed at enhancing good laboratory practices.

James B. Lucas
Acting Director
Health Effects Research Laboratory

ABSTRACT

Uncertified commercial research animal feed (Purina Chow™) was analyzed over forty-one months to determine essential and trace elements and toxic contaminants. Parametric statistics and graphic chronologic progressions of the results are presented for cat, monkey, rodent (rat/mouse), guinea pig and dog diets. Concentrations of toxic contaminants are discussed in terms of Maximum Allowable Concentrations (MAC) proposed by EPA. The impact of undesirable contaminants on in vivo animal studies is analyzed. Practical aspects of cost-effectiveness of feed analysis in a major research setting is discussed.

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INTRODUCTION

The sole purpose of this paper is the dissemination of factual scientific information about laboratory animal feed, and the contents cannot be construed as endorsement, or otherwise, by the United States Environmental Protection Agency for any feed product.

In recent years increasing attention has focused on nutritional and toxicological qualities of feed and water administered to experimental animals. Governmental regulations were proposed by the Food and Drug Administration, (Federal Register 1979a) and by EPA (Fed. Register 1979b) to control quality of non-clinical animal testing. Within the broad range of requirements for quality assurance, the Good Laboratory Practices (GLP) regulation mandates description and periodic analysis of animal feed.

Maximum Allowable Concentrations (MAC) for critical toxic substances in feed have been proposed by EPA based on the recommendation of the National Research Council's Committee for Long Term Holding of Laboratory Rodents (Fed. Reg. 1979c). The National Center for Toxicological Research (NCTR) set an internal MAC value for contaminants to be applied to all feed manufactured by the Center. Both sets of MAC values are listed in Table I.

In spite of the growing concern about feed contamination, only limited information is available in the literature about types, sources and timing of contamination.

Newberne and Fox (1980) dealt extensively with rodent feed contamination and its potential impact on toxicological procedures. Their list of multiple assays on rodent chow provides neither source nor chronology of sampling. With the exception of Coleman and Tardiff's earlier report (1979) dealing with the first twelve months progress of this project, no systematic or long term tracking of animal feed has been reported.

The need for controlling toxicants in animal feed has been recognized by the responsible and experienced manufacturing community. Recently, Shelton (1980) of the Ralston Purina Company outlined status and future plans within the industry for improved quality control. In his paper Shelton projected a certification profile for feed, and described methods for improved packaging, shipping and storage.

This paper summarizes our laboratory's experiences since Mid 1976 in testing uncertified animal diets. In compliance with Agency-wide policy for quality assurance and in anticipation of the imminent GLP regulations, we initiated analyzing all batches of feed purchased from Purina. The mode of analysis was retrospective, e.g. sampling and analysis was done immedi-

Table I

Maximum Allowable Concentrations of Toxic Feed Contaminants

CONTAMINANT	UNIT	USEPA	NCTR	MIN. REQ.
Cadmium	mcg/g	0.16	0.05	-
Lead	mcg/g	1.5	1.00	-
Arsenic	mcg/g	1.0	0.25	-
Mercury	mcg/g	0.1	0.05	-
Selenium	mcg/g	0.6	0.5	0.1
PCBs	ng/g	50	50	-
DDTs	ng/g	100	50	-
Malathion	mcg/g	2.5	0.5	-
Lindane	ng/g	20	10	-
Dieldrin	ng/g	20	10	-
Aflatoxins (Total)	ng/g	5	1.0	-
Estrogenic Activity (DES Equiv.)	ng/g	1	2	-

ately upon receipt of the feed lot. Assay data was available a month later, by which time the feed was dispensed for consumption.

The project included diet types of the following designation: (Number of batches tested are specified in parentheses.)

Standard Cat Chow*	(41)
High Protein Monkey Chow Catalogue #5045	(38)
Rodent Laboratory Chow #5001	(40)
Laboratory Rabbit Chow #5321	(35)
Guinea Pig Chow #5025	(17)
Purina Puppy Chow*	(11)

Thirty components were assayed in each of these formulae during varying segments of 41 contiguous months, from June'76 to December '79 inclusive. Classification of these was as follows:

A. Essential elements, for which the manufacturer specifies values in composition charts, usually published in sales catalogues.

Na	Ca	P	Fe	Zn	Cr
K	Mg	Se	Cu	Mn	

B. Toxic elemental and molecular contaminants for which MACs have been proposed by EPA.

Pb Hg Cd Se
Polychlorinated biphenyls
Organophosphorus and chlorinated pesticides
(Malathion, Parathion, Diazinon, Lindane, Heptachlor, DDTs)
Antibiotics (Penicillin, Streptomycin, Tetracyclines) Aflatoxin
(B_1, B_2) (Table II)
Estrogenic activity (DES equivalent)

C. Elements of undefined significance. The manufacturer neither attempts to control these, nor provides statements regarding levels in feed.

Al	Ba	Sr	B

Other nutrients, vitamins and feed ingredients were not included in the study.

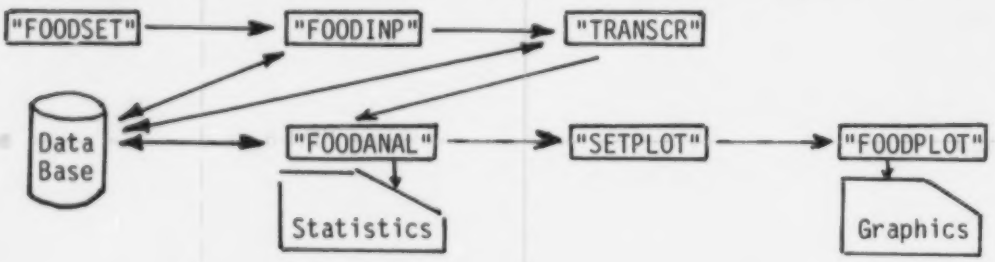
The intent of this paper is to: provide a chronological "snapshot" of a popular commercial feed; discuss the appropriateness of MACs; and evaluate methods of feed analysis.

*Manufactured primarily for the consumer market.

Materials and Methods: Means of sample collection and storage were previously described by Coleman and Tardiff (1979). All analyses were performed by the Raltech Co., Madison, Wisconsin under EPA Contract No. 68-03-2443. Table II links components with methodologies and detection limits as employed by the contractor. Individual assay results for As, Cd, Pb, Hg, Mn and Se were corrected for the corresponding recoveries reported by the analyst.

Analytical recoveries and the associated parametric statistics are listed in Table A-22.

Data storage and analysis were performed using a WANG VP computer. The following sequence of serial algorithms were written in BASIC-2:



The functions of these subroutines are as follows:

"FOODSET" - A primary eclectic screen dialogue enabling selection and establishment of a multi-dimensional data file on disk called "FOODAT," in which all analytical data is stored.

"FOODINP" - A formatted and auto-verified data entry routine to facilitate raw data entry and editing. Entry is either manual keyboard or by punched paper tape.

"TRANSCR" - Permits orderly sorting and re-ordering of raw data by select attributes, e.g. chronology, feed type, feed component, etc.

"FOODANAL" - Is the primary statistical routine calaculating parametric values, and storing these on disk data files called "FOODSTAT."

"SETPLOT" - A primary screen dialogue enabling formatting of the plotter routine parameters rolled in during the actual plotting subroutine called "FOODPLOT." Parameters are stored in a disk file called "PLOTDAT."

"FOODPLOT" - Is a universal scientific graph generator specially adapted to handle the food data.

RESULTS

Essential Element Group: A matrix of Co-efficients of Variations

Table II

CONTAMINANT	AUTHOR, OR REFERENCE	LIMIT OF DETECTION
Arsenic	AOAC 1975	.05 mcg/g
Cadmium	AOAC 1975	.05mcg/g
Manganese	AOAC 1975	.11 mcg/g
Lead	AOAC 1975	.05 mcg/g
Selenium	Gutteman and Lisk 1961	.05 mcg/g
Mercury	Hatch and Ott 1968	.05 mcg/g
All Others by ICP		
Aflatoxin (B_1,B_2,G_1,G_2)	Pons et al., 1975	2.00 ng/g
Organophosphorus & Chlorinated Insecticides	AOAC 1975	5.00 ng/g
Polychlorinated Biphenyls	AOAC 1975	10.00 ng/g
Chlortetracycline	AOAC 1975	.55 mcg/g
Oxytetracycline	AOAC 1975	1.21 mcg/g
Penicillin	AOAC 1975	2.20 mcg/g
Streptomycin	AOAC 1975	2.80 mcg/g
Estrogenic Activity (DES Equiv.)	NCTR 1973	4.00 ng/g

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(CV%) for these elements excluding selenium is listed in Table III. Tabulated summary of each element in this group can be located in Appendix A.

Toxic Contaminants: Elements - Table IV summarizes statistical parameters calculated for this group, and Tables A-15 to A-18 and Figures A-15 to A-18 summarize statistics and chronologic progressions for As, Cd, Pb and Se, respectively. Mercury was detected only in June 1979 in cat and monkey diets.

Molecular Contaminants: The following organics were undetectable in any feed; parathion, diazinon, aflatoxins, aldrin, antibiotics, or estrogens. Dieldrin was detected once in rabbit chow and twice in rodent and dog chows. Endrin was detected once in monkey chow.

A statistical summary for malathion, DDTs, and PCBs is provided in Table V. The respective temporal progressions are graphically presented in Figures A-19 to A-21 and in Tables A-19 to A-21.

Applying the rodent feed MACs of Table I as the basis of comparison for all feed types, Table VI lists percentages of all observations exceeding the EPA MAC (%V-EPA), exceeding the NCTR MAC (%V-NCTR), and the percentage of all observations beyond the Mean + 2SD limits in all feeds (%Ou).

Table VII lists all excessive occurrences in rodent feed, and Table VIII demonstrates excessive occurrences of cadmium in all feed types.

Elements of undefined significance - This group consists of aluminum, barium, strontium and boron. Their parametric statistics are summarized in Table IX, and Appendix A provides chronological progressions in the appropriate tables and figures.

DISCUSSION

Essential Elements - The range of variations (Table III) indicates reasonably rigid control in the manufacturing process. Mean concentrations shown in tables and figures in Appendix A of each elemental component are comparable across feed types, and correspond to those listed by the manufacturer in composition charts. The rodent values are close to those specified by NRC as recommended requirements (NRC 1979). Increasing and decreasing trends (signified by + or - in parentheses), although statistically significant, appear to be meaningless from the practical view. The following serves as an illustration of this statement:

The largest slope was found for zinc in Monkey Chow; A=4.4, B=9.8 for Y=A*X+B, N=27, $t=5.13_{df=25}$ ($t_{.01}=1.70$). An extrapolated zinc value for the 28th month was 111.4 mcg/g. This value does not appear to have practical importance when compared to the actual highest observed value of 179 mcg/g. (Throughout the 27 months of observation, the Monkey Chow zinc content ranged from 30-179 mg/kg.)

Table III

Coefficients of Variation (%) of Essential Elements in Feeds

ELEMENT	CAT	MONKEY	G. PIG	RODENT	RABBIT	DOG
P	19	16(+)	10(+)	14(+)	9(+)	9
K	12	10	13(-)	9(-)	11	9(-)
Na	30(+)	14	13(-)	18	15	9(-)
Mg	10(+)	17(+)	12(+)	12(+)	13(+)	8(+)
Ca	14(+)	12(+)	11	12(+)	9	9(+)
Fe	15(+)	20	14(-)	30	11	26(-)
Cu	37	50	18	23	13(-)	15(-)
Zn	24	51(+)	17(+)	15	19	18
Mn	25(-)	39(+)	13(+)	17(+)	11(+)	12(-)
Cr	66(-)	48	38	40	35	134

(+)= Statistically significant ($T > T_{.01}$) increasing slope

(-)= Statistically significant decreasing slope

TABLE IV

PARAMETRIC STATISTICS - TOXIC ELEMENTS

ELEMENT (mcg/g)		CAT	MONKEY	G. PIG	RODENT	RABBIT	DOG
PB	N	41	38	35	40	17	11
	$\bar{X}$	1.12	.37	.55	.58	.60	1.11
	Median	.79	.19	.48	.48	.52	.90
	SD	.92	.44	.24	.40	.24	.42
	CV%	82	118	42	69	40.7	37.9
	Range	.2-5.8	.06-2.47	.26-1.34	.26-2.59	.33-1.4	.6-1.87
Cd	N	41	38	35	40	17	11
	$\bar{X}$	.19	.15	.17	.15	.14	.19
	Median	.15	.12	.17	.15	.13	.07
	SD	.09	.14	.04	.05	.04	.4
	CV%	47.9	94.4	21.0	30.5	29.7	200
	Range	.09-.48	.07-.96	.10-25	.09-.26	.1-.29	0-1.3
AS	N	41	38	35	40	17	11
	$\bar{X}$	.36	.09	.18	.39	.13	.05
	Median	.33	.10	.17	.38	.15	0
	SD	.15	.08	.08	.09	.11	.07
	CV%	40.2	92.4	41.7	22.9	82.0	140.4
	Range	.11-.72	0.0-.23	0.0-.40	.17-.58	0-.39	0-1.17
Se	N	41	38	35	40	17	11
	$\bar{X}$	.38	.21	.35	.42	.43	.37
	Median	.31	.12	.26	.36	.34	.18
	SD	.18	.23	.18	.16	.22	.32
	CV%	47.6	110.9	55.6	39.1	50.6	86.5
	Range	.15-.96	.04-1.05	.11-.90	.24-1.04	.14-.85	.05-.94

TABLE V

PARAMETRIC STATISTICS - TOXIC MOLECULAR CONTAMINANTS

TOXICANT (Unit)		CAT	MONKEY	G. PIG	RODENT	RABBIT	DOG
Malathion (mcg/g)							
	N	41	38	35	40	17	11
	$\bar{X}$	.08	.09	.17	.11	.09	.05
	Median	0	.04	.1	.11	.06	.01
	SD	.16	.10	.23	.07	.77	.06
	CV%	199.4	115.2	129.4	62.6	83	124.4
	Range	0-.96	0-.400	0-1.20	0-.36	0-.28	0-.18
PCBs (ng/g)							
	N	40	37	33	39	17	11
	$\bar{X}$	6.75	2.51	4.48	19.61	2.23	0
	Median	0	0	0	0	0	0
	SD	14.73	7.31	8.19	33.59	5.06	0
	CV%	218.2	290.7	182.6	171.2	226.1	-
	Range	0-57	0-36	0-31	0-185	0-15	0-0
DDTs (ng/g)							
	N	40	37	34	39	17	11
	$\bar{X}$	3.1	.22	2.73	13.74	.35	0
	Median	0	0	0	0	0	0
	SD	7.57	1.31	9.2	21.8	1.46	0
	CV%	244	608	336	158	412	-
	Range	0-26	0-8	0-47	0-84	0-6	0-0

TABLE VI

EXCESSES OF MAX. ALLOWABLE CONCENTRATION IN SIX FEED TYPES

TOXIC CONTAMINANT	%V(EPA)	%V(NCTR)	%Ou(DSD)
Lead	10.5	18.5	3.1
Arsenic	0	43.3	2.1
Cadmium	38.0	98.9	4.2
Mercury	3.7	4.7	1.5
Selenium	16.9	25.9	3.1
PCBs	6.5	6.5	6.5
DDTs	3.7	5.9	6.4

%V= Percentage of all occurences violating EPA/NCTR MACs

%Ou= Percentage of outliers beyond $\pm$ 2 SD

TABLE VII

EXCESSES OF MAX. ALLOWABLE CONCENTRATIONS IN RODENT (RAT/MOUSE) DIET

TOXIC CONTAMINANT	%V(EPA)	%V(NCTR)	%Ou(DSD)
Lead	7.3	9.7	4.8
Arsenic	0	93.0	0.0
Cadmium	34.1	100.0	4.8
Mercury	2.5	2.5	2.5
Selenium	17.0	31.7	2.4
PCBs	10.0	10.0	2.5
DDTs	2.5	12.5	7.5

TABLE VIII

EXCESSES OF MAX. ALLOWABLE CONCENTRATION OF CADMIUM* IN SIX ANIMAL DIETS

DIET TYPE	%V(EPA)	%V(NCTR)	%Ou(DSD)
Cat	48.7	100.0	4.8
Monkey	17.9	100.0	2.5
G. Pig	68.4	100.0	2.6
Rodent (Rat/Mouse)	34.1	100.0	4.8
Rabbit	21.0	100.0	5.2
Dog	9.0	81.8	9.0

* MAC for cadmium issued by both institutions is based on rat diet.

TABLE IX

PARAMETRIC STATISTICS - ELEMENTAL CONTAMINANTS
OF UNDEFINED SIGNIFICANCE

ELEMENT (mcg/g)		CAT	MONKEY	G. PIG	RODENT	RABBIT	DOG
	N	30	27	24	28	9	11
Al	$\bar{X}$	107	112	213	186	179	66
	Median	101	112	217	178	175	51
	SD	32.5	18.6	29.7	38.7	20.5	27.7
	CV%	30.4	16.6	14.0	20.8	11.5	42.0
	Range	56-179	80-162	137-256	117-310	150-216	39-130
	$\bar{X}$+2SD	172	149	272	263	220	121
	N	29	26	23	27	9	11
	$\bar{X}$	3.7	6.2	18.9	12.9	22.0	11.9
Ba	Median	3.8	6.4	18.0	12.8	21.7	10.6
	SD	.73	2.93	5.6	2.93	3.91	2.94
	CV%	19.5	47.3	29.7	22.7	17.7	24.7
	Range	2.5-5	1.9-10.8	10.3-31.5	7.9-18.5	15.3-27.8	8.8-18
	$\bar{X}$+2SD	5.1	12.0	30	18.9	28	18
	N	30	27	24	28	9	11
	$\bar{X}$	16.8	10.6	29.0	21.0	30.1	12.9
Sr	Median	13.5	11.8	28.8	21.6	28.5	11
	SD	7.5	3.7	8.5	5.2	4.4	4.9
	CV%	44.3	35	29.1	24.6	14.7	37.9
	Range	3.3-33.5	3.0-15.1	16.4-43.5	11.9-31.7	22.4-37.6	2.6-20.23
	$\bar{X}$+2SD	32	18	46	32	39	23
	N	30	27	24	28	9	11
	$\bar{X}$	10.2	12.8	17.2	13.1	15.1	8.5
B	Median	8.9	12.6	17.1	13.0	14.8	7.8
	SD	5.2	3.3	2.6	2.3	2.0	2.7
	CV%	51.1	25.5	15.1	17.5	13.6	32.1
	Range	1.9-29.9	5.8-21.3	10.9-21.3	7.8-17.9	11.2-18.7	5.2-14
	$\bar{X}$+2SD	20	19	22	18	19	14

Toxic Contaminants - For toxicologists, three attributes of "toxicological suitability" of animal diet should rank foremost; absence of toxic contaminant levels in excess of scientifically established "no effect" concentration, absence of undesirable time trends signifying consistency of composition, plus high degree of confidence in these requirements.

The sudden appearance of untolerable contamination in animal diets can have disastrous consequences on a toxicological study. Depending on the substance tested and on the endpoints measured, the study director must decide in advance when and for which contaminants feed should be subjected to surveillance.

Certified formulations may be twice as expensive as uncertified formulae, while pre-administration analysis followed by interim storage of feed until proven acceptable, may be equally expensive. In the current economy, cost of a single animal study may reach five or six figures depending on the chronicity of the study, a 10-20% portion of which is spent on husbandry. Thus, in an effort to minimize expenditures, the study director would likely elect to depend on a retrospective feed assay. This option is feasible only if: a) the past performance of the manufacturer is known; b) the historical rate of background accumulation of toxicants is insignificant, (e.g., heavy metals in basic feed ingredients); or c) the probability for accidental spills (e.g., PCBs) or for regional/seasonal overuse (pesticides) is low. Hence, the temporal behaviour of a contaminant partly attests to the quality control in manufacturing. Furthermore, it can serve as a warning for background accumulation. Should one contaminant appear simultaneously in more than one feed type, it may appear that one formulation ingredient common to all feeds was contaminated.

Practical implications of these considerations are discussed for each toxic contaminant in the following:

Lead - The variability of this element was particularly high in cat, monkey and rodent chows (Table IV and A-17). The ambient range in rodent feed presented a practical concern to our investigators because of a previous experience. During 1978, a large rat cross-fostering study involving low lead levels in drinking water had to be invalidated because of an outlier (2.59 mcg/g) lead level occurring in rodent chow (R. J. Bull, personal communication). The interference was detected by the investigators before retrospective levels became available one month later. The same sampling period also disclosed outliers in cat, monkey and rabbit diets (Figure A-17). These data were corrected for recovery efficiencies, discounting analytical error.

Using the EPA and NCTR MAC lead values for rodent feed as a base, (Table VI), 10.5% of all observations of all feeds exceeded the EPA MAC, while 18.5% exceeded the NCTR limit, and 3.1% of all observations fell in the range of outliers. Corresponding excursions in rodent feed (Table VII) show a similar pattern.

Cadmium - Remarkably, more than one third of all observations on all feed types exceeded the EPA limit, and virtually all were beyond the NCTR MAC (Table VIII). This emphasizes the constant dilemma of how to establish regulatory limits, both realistically and cost-effectively. Had we obtained the monthly analytical data before we administered the feed to our rodents, based on the EPA MAC, we would have had to reject 34% of the lots. In practice, the exclusion of the diets exceeding the arbitrary MACs was not necessary due to the nature of the studies being undertaken in our laboratory.

One may question the purpose of MAC limits, if such limits do not become the basis for quality judgement. Knapka (1980) noted the controversial nature of the EPA MAC values, and the algorithm by which such limits have been set in the past. Knapka lists two valid criteria for setting limits of this type:

a. Knowledge of actual historical variations of contaminants in feed (e.g., what is realistic and permitted by nature).

b. Hard scientific data supporting biological effects at concentrations one may anticipate.

Knapka further argues that one may possibly ban some carcinogens altogether from animal feed on the basis of the zero threshold theory. Some heavy metals may, in fact, have nutritional trace elemental qualities, as was the case with selenium. Perhaps, the only stumbling block is that we do not yet know what those levels are. While we have no indication as to the bio-essentiality of Cd, we know from past rodent studies that cadmium has no adverse effects on rodents up to 5 mcg/ml concentrations in drinking water, (Decker 1958, Levy 1973), nor is cadmium carcinogenic at such dose levels (Schroeder 1964).

Visual examination of the cadmium plot (Figure A-16) suggests that the rodent chow was remarkably stable in this contaminant, unlike the dog, monkey and cat feeds where outliers occurred. It is also clear from the plot that the majority of all observations in all feed types fell below .5 mcg/g. This level could be regarded as a reasonably expectable natural occurrence. The data presented here may provide the basis for amending the present EPA MAC of .15 mcg/g, which is neither realistic nor enforceable. Undoubtedly, there will be experiments performed in which .5 mcg/g cadmium levels cannot be tolerated. In such cases a controlled or synthetic diet is a must. Alternatively, the research institution must be prepared to manufacture its own feed, as it is done at NCTR.

Mercury - This contaminant was detected only in June 1979 in cat and rodent feeds, both being lower than the MAC recommended by EPA.

Arsenic - Arsenic appears to be the most variable of all contaminants across feed types (Figure A-15). Lowest mean concentration of 0.52 mcg/g

was in dog feed, and the highest of 39 mcg/g in rodent feed. Again a large discrepancy exists between the NCTR and EPA limits. Over 90% of all observations exceeded the NCTR MAC while none exceeded the EPA MAC. Repeatedly, one may question either the validity of the EPA MAC of 1.0 mcg/g, or the NCTR limit of .25 mcg/g, especially since arsenic is a known carcinogen. Purely on the basis of natural occurrence, it could be suggested that the EPA MAC be lowered to about .6 mcg/g.

Selenium - The chronological progression of this element shows an excellent example of a sudden and simultaneous elevation in all feeds, followed by persistence and slow decay (Figure A-18). Abruptly, in March 1979, all feeds examined showed elevations beyond the EPA MAC, and most persisted with gradual attenuation until August 1979. It should be noted that selenium is an essential element with a minimum dietary requirement of 0.1 mcg/g established for rodents (Table I). It is noteworthy that 14 samples of monkey diet fell below this level, although it should be stressed that primate requirements for selenium have not been found in the literature.

In retrospect, a deficiency of our study was that the chemical form of this element (selenite versus selenate) was not defined by the analytical procedure. Palmer and Olson (1974) have shown that 2 mcg/ml of selenite reduced weight gain in rats, but did not increase mortality when administered in drinking water for 6 weeks. Earlier Schroeder and Mitchener (1971) reported severe toxicity of selenite in rats at 2 mcg/ml, but not with selenate. Halverson (1966) demonstrated that post-weanling rats suffered no ill effects when fed natural selenium (in grain) up to 6.4 mcg/g concentration for 6 weeks. Pletnikova (1970) reported that selenium .5 mcg/kg/day for 6 months in rats resulted in decreased liver function as measured by bromsulphalein clearance.

The toxicity of selenium is dependent on the type of diet the animal receives. Harr and Muth (1972) have shown the minimum toxic level for Se in semi-purified diet is .25 mcg/g for rats, while the same animals thrived on a natural diet containing .5 mcg/g. They concluded that the pathologic threshold is 3.0 mcg/g. In view of these inconsistencies, it is not possible to judge the effects of the transient elevation of Se experienced in early 1979 on our animals. In light of the natural progression, the EPA MAC value appears to reflect a realisic limit.

Malathion - Malathion is the most stable and best controlled pesticide residue in all diets tested (Figure A-19). Purely on the basis of temporal incidences, one is tempted to choose the NCTR MAC over the EPA limit of 2.5 mcg/g, which is about twice that of the highest concentration observed (1.2 mcg/g) in guinea pig chow.

DDTs - DDTs are ubiquitous contaminants (Figure A-21) appearing in spikes at regular frequency throughout the study, suggesting seasonality. The absolute maximum observed in rodent diet was 88 ng/g, much below the 200 and 400 ng/g used by Kemeny and Tarjan (1969) as a control diet in a six generation carcinogenicity study using BALB/C mice. Laug (1950) fed rats

for 15-27 weeks at the 1000 ng/g level. No hepatic cell alterations could be detected, and minimal pathology was seen at 5000 ng/g. Based on this information, the DDT contamination of the feed samples was considered of no consequence.

PCBs - Rodent diet, the most frequently encountered in toxicological laboratories, showed two instances of contamination. One occurred in March 1978 when levels reached 185 ng/g (Figure A-20). A rodent colony consuming this feed ingested an estimated total body dose of 5-6 mcg/kg/day, representing a monthly burden of .15 - .18 mg/kg for a 30 day period.

PCBs are known to induce liver microsomal enzymes. Dietary threshold for mixed function oxidase induction was estimated by Villenue et al., (1971), Litterst et al., (1972) and Turner and Green, (1974) to range between 500-25000 ng/g in feed for various laboratory animals. In rats 1000 ng/g in feed did not induce liver enzymes according to Bruckner et al., (1977). Based on these reports, it is our conclusion that the 185 ng/g contamination peak was not sufficient to alter liver function in our animals. However, PCBs are known carcinogens (NCI 1978), and based on this fact, we would have probably discarded the contaminated lot had we known beforehand.

Newberne (1980) points out the danger of accidental contamination of livestock and poultry with PBBs and PCBs, quoting recent spills in the United States. Since electrical equipment containing PCBs are still in use in feed processing plants, accidental spills are possible to occur, (Willett and Hess 1975). The need for pre-administration surveillance of PCB in feed is warranted.

Elements of Undefined Significance

Aluminum - Recently, Levick (1981) expressed concern over the possible neuro-toxic effects of aluminum in human foodstuffs associated with the use of aluminum cooking utensils. Trapp and Cannon (1981) as well as Koning (1981) took exception to Levick's conclusions, referring to the works of Ondreicka (1971) and Schmidt (1919), who showed that most dietary aluminum passes unabsorbed through the G.I. tract. Furthermore, Koening points out the potentially large doses of aluminum ingested in the form of antacid preparations without ill effects, such as seen in Alzheimer's disease (Crapper et al., 1973) and in dialysis encephalopathy (Alfrey et al., 1976). In view of this human experience, one cannot speculate as to the significance of aluminum in animal feeds (Tables IX and A-6). The highest observed level of 310 mcg/g (Figure A-6) in rodent feed is about 10-fold over the level one might find in human food (oatmeal) cooked in aluminum pots (Koning 1981). From the analytical data, it is not possible to discern in what chemical form aluminum is present in animal feed. One may suspect that most are in the form of inert oxides and silicates, which are ubiquitous components of soil matrix.

Barium - The cardiovascular toxicology of this element received considerable attention, especially in view of its abundance in drinking

water (EPA 1979). Its effects on smooth, striated and cardiac muscle (Roza and Berman 1971), on hypertension (Diengott et al., 1964), bone proliferation (Goodman 1970), and catecholamine release from adrenergic synapses in animals (Tardiff et al., 1980) are current topics of widespread research. Thus, feed barium levels are of significant interest to many researchers.

An example of this emerged in our laboratory, when the rate of gastrointestinal absorption of naturally occurring barium in drinking water was studied in rats. The study had to be repeated after the investigators realized that the ambient feed levels interfered with the interpretation, since the rat chow contained 2-5 times the amount of barium that was present in the water sample studied (Bull and McCauley, personal communication, 1981). (Table A-7 and Figure A-7).

Future toxicologic findings on barium will probably necessitate closer control of this element in animal feed.

Strontium and Boron - Very little is known about the potential impact of these contaminants in the ppm range in animal studies. (Tables A-9 and A-10, Figures A-9 and A-10).

CONCLUSIONS

During the past 41 months our average annual expenditures for animal care were as follows;

Cost of animal care contract:		$342,800
Includes $16,000 for feed purchase		
$66,000 for animal purchase		
Cost of feed analysis		$ 28,700
	TOTAL	$371,500

During this period, our laboratory personnel submitted to the Program Operations Office an average of 67 distinct test protocols per twelve months period involving use of test animals. Thus, the animal care contribution to the overall cost of one study was $5540. The scientific labor component of the total cost was $18,700 per study (based on FY'80 budget figures), and the sum of all costs was $24,340.

Consequently in our experience, feed analysis represented an average of $428.35 per study or 1.77% of all costs. Adding the cost of feed to the cost of analysis, we obtain 2.75%. During the three and half years, we had to invalidate two finite animal studies, representing a loss of .571 fraction of a study annually, or a yearly sum of $13,835, purely because we conducted retrospective feed surveillance.

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From the foregoing. it is evident that under our circumstances purchasing certified formulae would have been more cost effective:

Estimated cost of certified feed:	$32,000
Cost of unassayed open formula	$16,000
Cost of analysis	28,700
Cost of invalidated study	13,835
Net potential savings	$25,835

It is also clear that the methods of feed testing cannot be uniformly prescribed and will be dependent on the testing profile and unique needs of a laboratory. Commerical laboratories mainly performing short term studies can probably depend on occassional spot analysis of uncertified formulae, without being encumbered by prohibitive expenditures. Our average cost per feed component was $19.10.

In contrast to short-term testing laboratories, long-term testing facilities where expensive lifetime studies are conducted should depend on "certified feed," for which the manufacturer attaches certification profiles at the time of delivery.

Finally, the selection of the target contaminants in testing feed should be discussed. Two guidelines appear to be appropriate for choosing target contaminants and/or essential elements: pertinence to biological endpoints or impact on potential interferences, (e.g., this writer (JPB) regrets that our project did not involve iodine as an essential element since past thyroid function studies with primates would have had definite use for such data); bio-availability and chemical state if indicated, (e.g., the case of selenium and aluminum mentioned before, or in case of iron, where feed may contain biologically unavailable iron oxides.)

It is hoped that the experiences derived from this project will assist laboratory animal science, enhancing both validity and cost-effectiveness of testing.

Recommendations: The lesson from this project is clear: Future feed surveillance mechanisms must be forward looking, eclectic and flexible to allow biological endpoint-oriented tracking of contaminants for the duration of the study it intends to support. The retrospective mode such as presented in this paper in unable to prevent interferences, furthermore it may obfuscate rather than clarify the experimental data. The data must be presented to the end users with clarity, and with meaningful statistical parameters, preferably reinforced with graphics, such as shown in the pages of Appendix A.

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--- Arsenic, secs. 25.008, 25.012-25.013. Utilizing the nitric acid, sulfuric acid, perchloric acid digestion.
--- Cadmium, secs. 25.026-25.030,25.068.

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--- Lead, (Samples with less than 4.00 ppm), secs. 25.065-25.070.
(Samples with more than 4.00 ppm), secs. 25.077-25.082.
--- PCBs and Pesticides, secs. 29.011(d) and (e).
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Willett, L.B. and J.F. Hess, Jr., Polychlorinated biphenyls in silos in the United States. Residue Rev. (1975) 55: 135.

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Table A-1. Phosphorus (%)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	-	-	-	-	-	-
76/09	-	-	-	-	-	-
76/10	-	-	-	-	-	-
76/11	-	-	-	-	-	-
76/12	-	-	-	-	-	-
77/01	-	-	-	-	-	-
77/02	-	-	-	-	-	-
77/03	-	-	-	-	-	-
77/04	-	-	-	-	-	-
77/05	-	-	-	-	-	-
77/06	-	-	-	-	-	-
77/07	.8660	.5400	.5500	.6870	.4060	-
77/08	.9430	.5920	.5860	.7780	-	-
77/09	.9390	.5470	.6380	.6770	-	-
77/10	.9640	.5320	.5750	.6870	-	-
77/11	.9760	.5370	.5960	.6930	-	-
77/12	1.040	.5820	-	.7130	-	-
78/01	1.010	.5790	.5370	.6980	-	-
78/02	.9740	.5200	.5190	.6940	-	-
78/03	1.020	.5770	.5160	.7220	-	-
78/04	1.200	.5390	.4705	.7140	-	-
78/05	1.335	.6590	.6020	.9160	-	-
78/06	1.245	.6040	.5790	.8600	-	-
78/07	1.036	.6270	.5960	.8890	-	-
78/08	1.035	.6300	.6400	-	-	-
78/09	1.146	.6520	.6570	.9740	-	-
78/10	1.093	.6860	.6560	.9170	-	-
78/11	.9680	.6970	.6110	.9620	-	-
78/12	.8920	-	-	.9330	.4970	1.233
79/01	1.025	.6760	.7780	.9040	.5400	1.163
79/02	.9900	.8020	.6280	.9740	-	1.362
79/03	1.042	.7450	.6900	1.025	.5530	1.261
79/04	1.122	.7980	.6720	1.074	.5740	1.484
79/05	1.008	.8500	.6120	.9360	.5300	1.208
79/06	.9200	-	.6460	.8040	-	-
79/07	.1600	.5420	.6000	.8800	.5400	1.178
79/08	1.022	.8760	-	.9870	.5140	1.306
79/09	1.000	.6920	.5840	.8900	-	-
79/10	1.061	.7700	-	-	-	1.227
79/11	1.070	-	-	.9380	-	1.128
79/12	.9990	.6720	-	.8920	.5580	1.102
No.Obs.	30.00	27.00	24.00	28.00	9.000	11.00
Mean	1.003	.6490	.6057	.8506	.5235	1.241
Median	1.010	.6270	.6000	.8890	.5300	1.208
S.D.M.	.1880	.1033	.0643	.1215	.0497	.1103
S.E.E.	-	.0699	.0567	.0800	.0258	-
C.V.	18.73	15.92	10.61	14.28	9.501	8.892
Slope	-	.0087	.0038	.0104	.0051	-
Y-Intercept	-	.4249	.5102	.5790	.3600	-
Coeff.Det.(r↑2)	-	.5421	.2222	.5660	.7301	-
t (.01)	( )	5.43 (1.70)	2.50 (1.71)	5.82 (1.70)	4.35 (1.83)	( )
Range	.160 1.33	.520 .876	.470 .778	.677 1.07	.406 .574	1.10 1.48

Figure A-1.

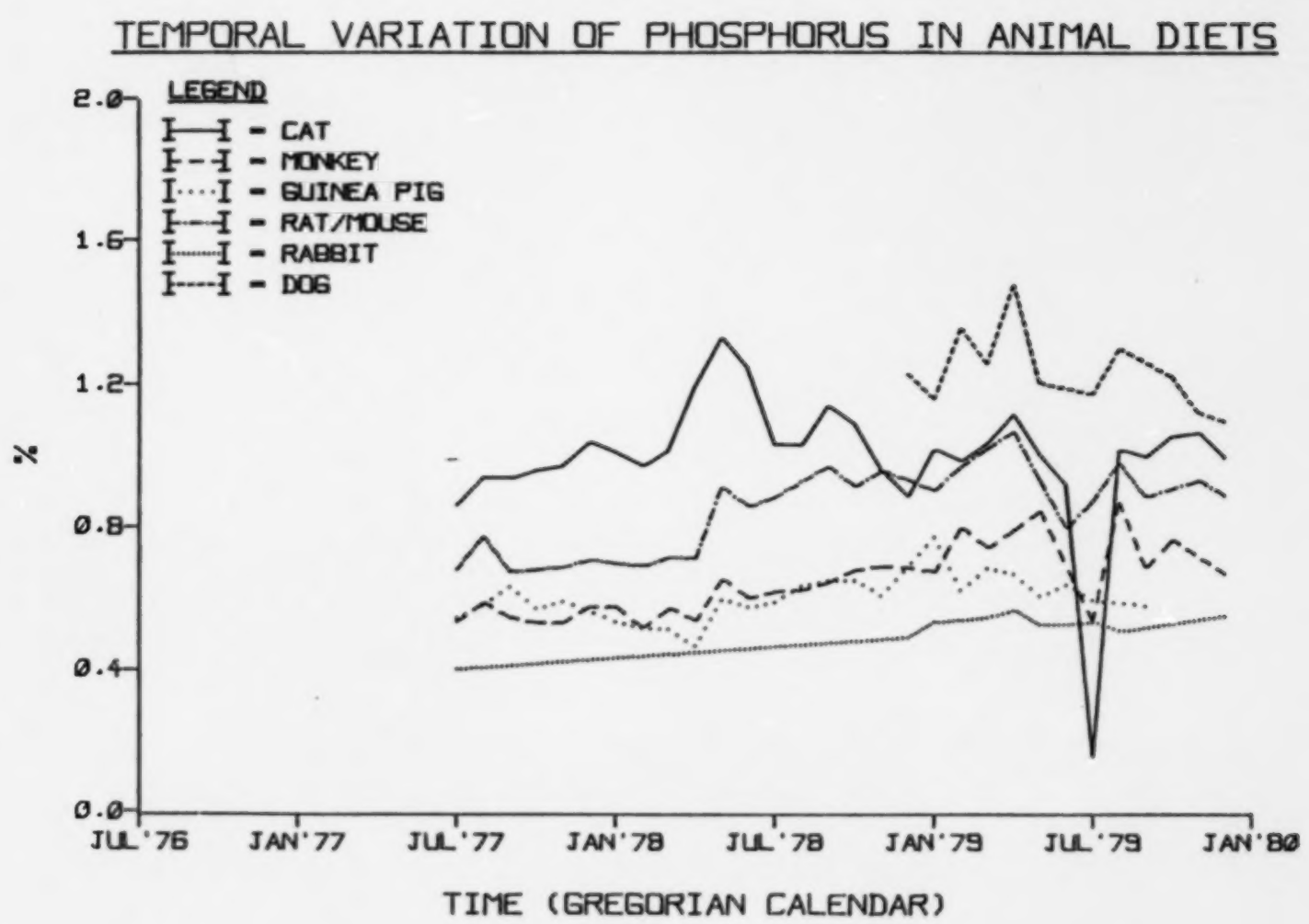
TEMPORAL VARIATION OF PHOSPHORUS IN ANIMAL DIETS
LEGEND
CAT
MONKEY
GUINEA PIG
RAT/MOUSE
RABBIT
DOG
2.0
1.6
1.2
0.8
0.4
0.0
%
JUL'76
JAN'77
JUL'77
JAN'78
JUL'78
JAN'79
JUL'79
JAN'80
TIME (GREGORIAN CALENDAR)

Table A-2. Sodium (%)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	-	-	-	-	-	-
76/09	-	-	-	-	-	-
76/10	-	-	-	-	-	-
76/11	-	-	-	-	-	-
76/12	-	-	-	-	-	-
77/01	-	-	-	-	-	-
77/02	-	-	-	-	-	-
77/03	-	-	-	-	-	-
77/04	-	-	-	-	-	-
77/05	-	-	-	-	-	-
77/06	-	-	-	-	-	-
77/07	.7180	.2140	.3300	.4180	.2200	-
77/08	.6070	.2150	.3280	.3610	-	-
77/09	.6340	.2250	.3510	.2900	-	-
77/10	.5580	.2430	.3460	.3540	-	-
77/11	.5680	.2160	.3780	.3160	-	-
77/12	.5400	.1920	-	.3860	-	-
78/01	.7090	.1770	.3390	.4630	-	-
78/02	.6210	.1940	.3140	.3610	-	-
78/03	.6340	.2210	.3260	.5970	-	-
78/04	.6925	.2165	.3125	.5250	-	-
78/05	.5000	.1700	.2800	.3000	-	-
78/06	.3900	.1400	.2500	.3100	-	-
78/07	.5700	.1800	.3000	.2800	-	-
78/08	.5400	.2000	.3000	-	-	-
78/09	.6500	.2000	.2800	.3600	-	-
78/10	.6700	.1800	.2800	.4400	-	-
78/11	.5200	.1800	.2600	.4400	-	-
78/12	.4700	-	-	.3900	.2400	.5500
79/01	.2400	.1700	.3600	.4800	.2400	.4700
79/02	.4000	.1900	.3000	.3800	-	.5000
79/03	.3800	.3000	.3300	.4000	.2300	.5500
79/04	.3600	.2000	.2200	.4000	.2400	.5200
79/05	.3500	.1900	.2800	.3800	.2600	.5200
79/06	.2000	-	.2700	.3600	-	-
79/07	.3500	.2000	.2200	.3900	.2600	.5000
79/08	.3800	.1900	-	.4100	.2100	.5400
79/09	.3500	.2300	.3300	.3600	-	-
79/10	.3400	.1900	-	-	-	.4200
79/11	.3400	-	-	.3400	-	.4900
79/12	.3300	.2100	-	.3800	.3400	.4200
No.Obs.	30.00	27.00	24.00	28.00	9.000	11.00
Mean	.4870	.2012	.3035	.3882	.2488	.4981
Median	.5000	.1940	.3000	.3800	.2400	.5000
S.D.M.	.1473	.0293	.0414	.0697	.0378	.0460
S.E.E.	.0879	-	.0347	-	-	.0369
C.V.	30.25	14.60	13.65	17.96	15.22	9.234
Slope	-.013	-	-.002	-	-	-.006
Y-Intercept	.8429	-	.3747	-	-	.7271
Coeff.Det.(r↑2)	.6435	-	.2980	-	-	.3538
t (.01)	7.10 (1.64)	( )	3.05 (1.71)	( )	( )	2.21 (1.79)
Range	.200 .718	.140 .300	.220 .378	.280 .597	.210 .340	.420 .550

Figure A-2.

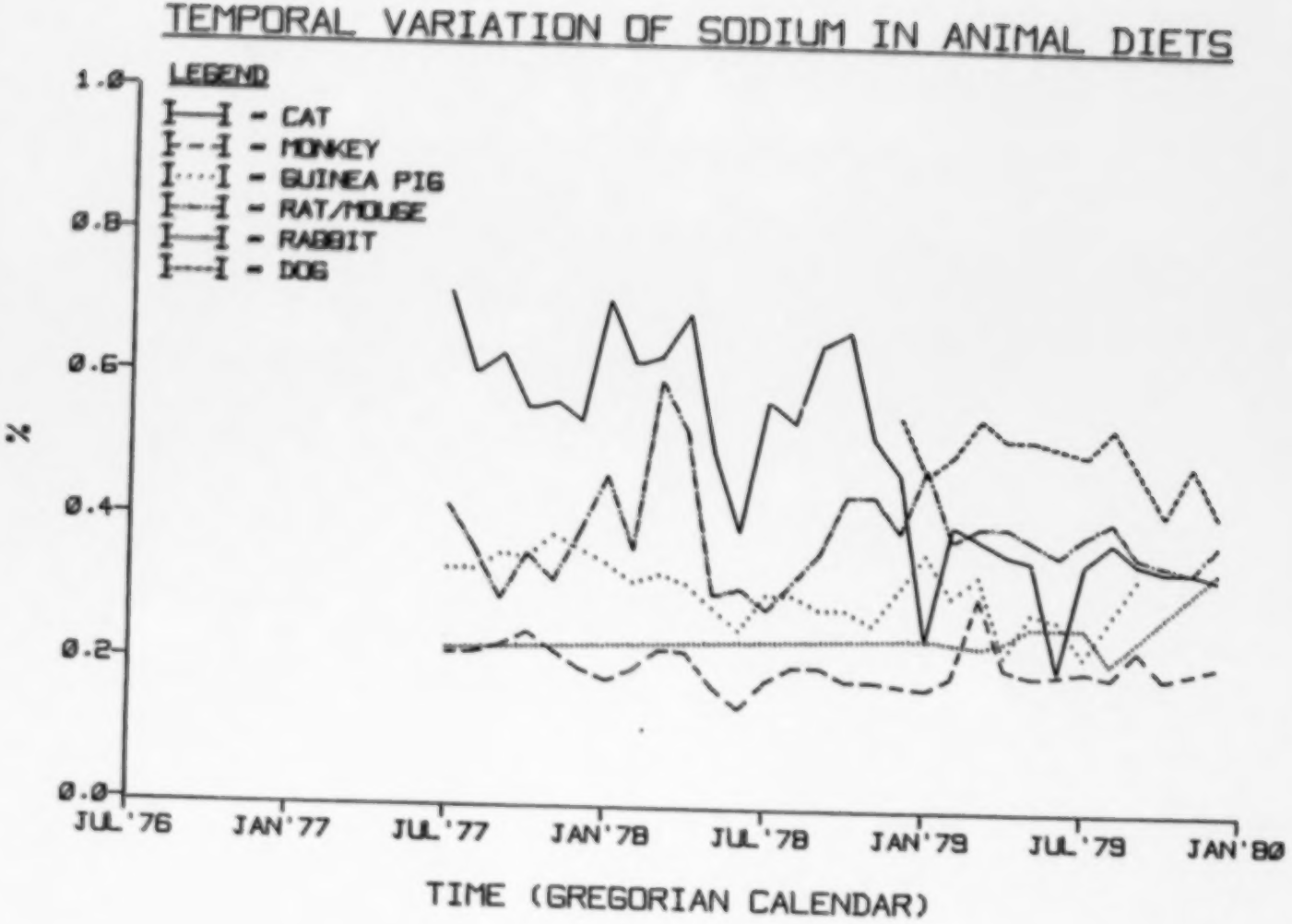
TEMPORAL VARIATION OF SODIUM IN ANIMAL DIETS
LEGEND
CAT
MONKEY
GUINEA PIG
RAT/MOUSE
RABBIT
DOG
1.0
0.8
0.6
0.4
0.2
0.0
%
JUL'76
JAN'77
JUL'77
JAN'78
JUL'78
JAN'79
JUL'79
JAN'80
TIME (GREGORIAN CALENDAR)

Table A-3. Potassium (%)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	-	-	-	-	-	-
76/09	-	-	-	-	-	-
76/10	-	-	-	-	-	-
76/11	-	-	-	-	-	-
76/12	-	-	-	-	-	-
77/01	-	-	-	-	-	-
77/02	-	-	-	-	-	-
77/03	-	-	-	-	-	-
77/04	-	-	-	-	-	-
77/05	-	-	-	-	-	-
77/06	-	-	-	-	-	-
77/07	.8280	1.040	1.840	1.260	1.600	-
77/08	.7980	1.100	1.810	1.260	-	-
77/09	.8560	1.130	1.930	1.310	-	-
77/10	.7930	1.080	1.820	1.300	-	-
77/11	.7660	.9880	1.830	1.310	-	-
77/12	.8440	1.150	-	1.360	-	-
78/01	.8620	1.060	1.760	1.280	-	-
78/02	.8050	1.180	1.750	1.200	-	-
78/03	.8680	1.080	1.680	1.340	-	-
78/04	.8660	1.055	1.630	1.270	-	-
78/05	.6300	.8000	1.250	.9800	-	-
78/06	.7800	.9800	1.310	1.060	-	-
78/07	.6400	.8900	1.360	1.060	-	-
78/08	.8000	1.110	1.660	-	-	-
78/09	.7600	.9400	1.460	1.130	-	-
78/10	.6800	.9500	1.320	1.040	-	-
78/11	.5400	.9200	1.520	1.020	-	-
78/12	.7400	-	-	1.240	1.720	1.000
79/01	.8200	1.110	1.500	1.270	1.580	.9600
79/02	.6600	1.090	1.600	1.180	-	.9000
79/03	.6400	.9200	1.470	1.060	1.310	.8800
79/04	.6400	1.020	1.480	1.060	1.380	.8200
79/05	.7100	1.210	1.980	1.380	1.840	.9800
79/06	.7700	-	1.340	1.140	-	-
79/07	.6200	.7600	1.480	1.100	1.400	.7600
79/08	.7700	.9800	-	1.200	1.400	.8000
79/09	.7300	.9700	1.340	1.090	-	-
79/10	.9600	1.020	-	-	-	.8400
79/11	.7300	-	-	1.190	-	.8800
79/12	.8600	1.150	-	1.270	1.530	.8200
No.Obs.	30.00	27.00	24.00	28.00	9.000	11.00
Mean	.7588	1.025	1.588	1.191	1.528	.8763
Median	.7700	1.020	1.520	1.200	1.400	.8400
S.D.M.	.0953	.1101	.2158	.1147	.1747	.0778
S.E.E.	-	-	.1798	.1077	-	.0613
C.V.	12.56	10.74	13.58	9.631	11.42	8.886
Slope	-	-	-.015	-.004	-	-.011
Y-Intercept	-	-	1.963	1.308	-	1.277
Coeff.Det.(r^2)	-	-	.3054	.1180	-	.3795
t (.01)	( )		( )	3.10 (1.71)	1.86 (1.70)	( )	2.34 (1.79)
Range	.540 .960	.760 1.21	1.25 1.98	.980 1.38	1.31 1.84	.760 1.00

Figure A-3.

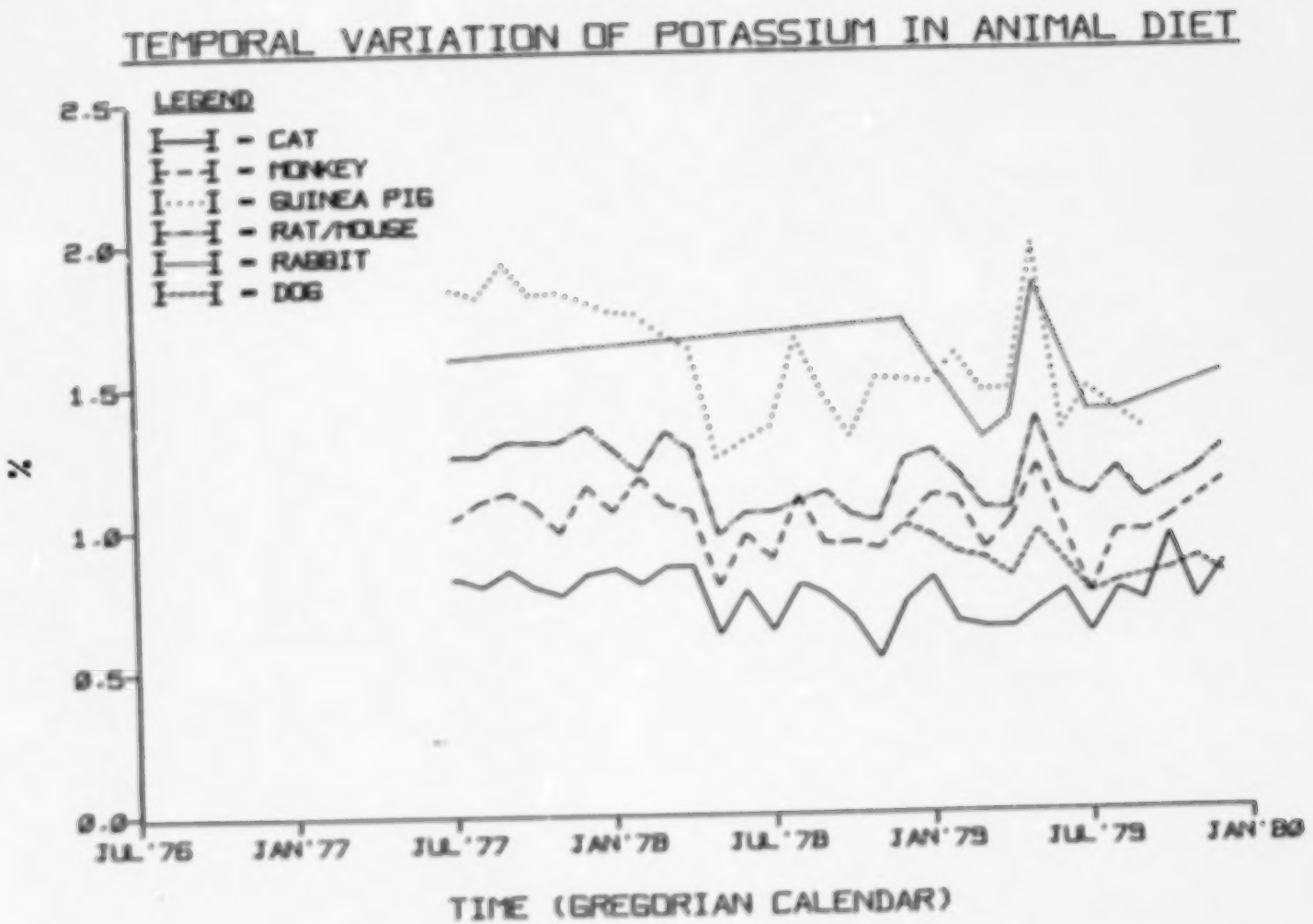
TEMPORAL VARIATION OF POTASSIUM IN ANIMAL DIET
LEGEND
I—I - CAT
I--I - MONKEY
I····I - GUINEA PIG
I—I - RAT/MOUSE
I—I - RABBIT
I—I - DOG
%
2.5
2.0
1.5
1.0
0.5
0.0
JUL '76
JAN '77
JUL '77
JAN '78
JUL '78
JAN '79
JUL '79
JAN '80
TIME (GREGORIAN CALENDAR)

Table A-4. Calcium (%)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	-	-	-	-	-	-
76/09	-	-	-	-	-	-
76/10	-	-	-	-	-	-
76/11	-	-	-	-	-	-
76/12	-	-	-	-	-	-
77/01	-	-	-	-	-	-
77/02	-	-	-	-	-	-
77/03	-	-	-	-	-	-
77/04	-	-	-	-	-	-
77/05	-	-	-	-	-	-
77/06	-	-	-	-	-	-
77/07	1.020	1.010	1.060	1.160	.8660	-
77/08	1.150	1.200	1.110	1.370	-	-
77/09	1.210	.9940	.9920	1.070	-	-
77/10	.9220	.9880	.9920	1.220	-	-
77/11	1.010	1.110	1.090	1.250	-	-
77/12	1.100	1.170	-	1.330	-	-
78/01	1.150	1.240	1.070	1.320	-	-
78/02	1.140	1.200	1.040	1.200	-	-
78/03	1.110	1.060	.9980	1.250	-	-
78/04	1.235	1.035	1.035	1.340	-	-
78/05	1.214	1.089	1.028	1.497	-	-
78/06	1.289	1.003	1.019	1.449	-	-
78/07	1.053	1.169	1.050	1.558	-	-
78/08	1.038	1.101	1.160	-	-	-
78/09	1.112	1.164	1.076	1.548	-	-
78/10	1.152	1.098	1.216	1.484	-	-
78/11	.9810	1.115	.9620	1.356	-	-
78/12	.9810	-	-	1.444	1.038	1.839
79/01	.8900	1.168	1.406	1.401	1.054	1.550
79/02	1.194	1.383	1.117	1.411	-	1.865
79/03	1.108	1.574	1.280	1.710	1.120	1.859
79/04	1.114	1.316	1.170	1.836	1.105	1.855
79/05	.9500	1.087	.9680	1.322	.8680	1.573
79/06	1.260	-	.8230	1.186	-	-
79/07	1.466	.9990	1.116	1.342	.9840	1.794
79/08	1.585	1.433	-	1.637	.9970	1.804
79/09	1.332	1.236	1.110	1.412	-	-
79/10	1.486	1.161	-	-	-	1.646
79/11	1.394	-	-	1.352	-	1.431
79/12	1.232	1.046	-	1.270	.9600	1.506
No.Obs.	30.00	27.00	24.00	28.00	9.000	11.00
Mean	1.162	1.153	1.078	1.379	.9991	1.702
Median	1.140	1.110	1.060	1.352	.9840	1.646
S.D.M.	.1690	.1421	.1160	.1721	.0915	.1634
S.E.E.	.1473	.1327	-	.1591	-	.1350
C.V.	14.54	12.32	10.76	12.47	9.161	9.601
Slope	.0094	.0058	-	.0074	-	-.022
Y-Intercept	.9131	1.003	-	1.184	-	2.472
Coeff.Det.(r^2)	.2402	.1280	-	.1453	-	.3173
t (.01)	2.97 (1.64)	1.91 (1.70)	( )	2.09 (1.70)	( )	2.04 (1.79)
Range	.890 1.58	.988 1.57	.823 1.40	1.07 1.83	.866 1.12	1.43 1.86

Figure A-4.

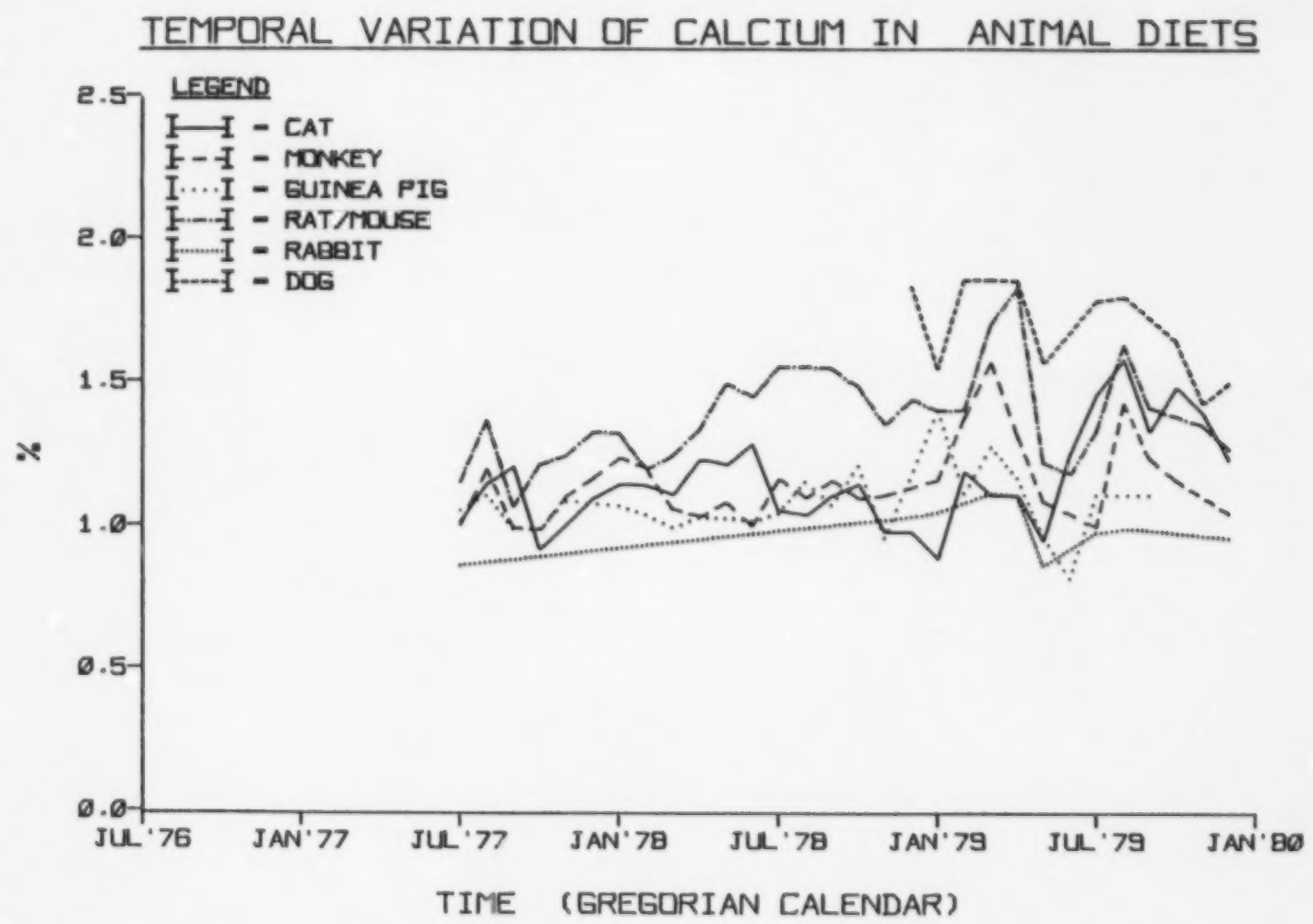
TEMPORAL VARIATION OF CALCIUM IN ANIMAL DIETS
LEGEND
CAT
MONKEY
GUINEA PIG
RAT/MOUSE
RABBIT
DOG
%
2.5
2.0
1.5
1.0
0.5
0.0
JUL'76
JAN'77
JUL'77
JAN'78
JUL'78
JAN'79
JUL'79
JAN'80
TIME (GREGORIAN CALENDAR)

Table A-5. Magnesium (%)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	-	-	-	-	-	-
76/09	-	-	-	-	-	-
76/10	-	-	-	-	-	-
76/11	-	-	-	-	-	-
76/12	-	-	-	-	-	-
77/01	-	-	-	-	-	-
77/02	-	-	-	-	-	-
77/03	-	-	-	-	-	-
77/04	-	-	-	-	-	-
77/05	-	-	-	-	-	-
77/06	-	-	-	-	-	-
77/07	.1180	.1380	.2800	.1740	.1880	-
77/08	.1170	.1460	.2690	.1830	-	-
77/09	.1180	.1390	.2970	.1710	-	-
77/10	.1100	.1440	.2850	.1790	-	-
77/11	.1160	.1430	.3090	.1890	-	-
77/12	.1170	.1480	-	.1860	-	-
78/01	.1170	.1430	.2900	.1750	-	-
78/02	.1140	.1450	.2280	.1680	-	-
78/03	.1210	.1500	.3000	.1840	-	-
78/04	.1300	.1770	.2880	.1875	-	-
78/05	.1300	.1890	.3060	.2100	-	-
78/06	.1290	.1860	.2980	.1970	-	-
78/07	.1260	.1880	.3080	.2020	-	-
78/08	.1200	.1820	.2960	-	-	-
78/09	.1340	.1860	.3480	.2100	-	-
78/10	.1360	.2120	.3300	.2010	-	-
78/11	.1420	.2250	.3600	.2140	-	-
78/12	.1360	-	-	.1000	.2370	.1920
79/01	.1510	.2160	.3300	.2040	.2540	.1960
79/02	.1720	.2260	.3740	.2080	-	.1980
79/03	.1420	.1940	.3780	.2050	.2720	.1940
79/04	.1460	.2340	.3860	.2380	.2740	.2120
79/05	.1300	.2050	.3700	.1960	.2700	.1780
79/06	.1320	-	.3320	.1780	-	-
79/07	.1270	.1790	.3100	.1900	.3140	.1620
79/08	.1260	.2050	-	.2120	.2600	.1820
79/09	.1320	.2160	.3480	.1980	-	-
79/10	.1460	.2240	-	-	-	.1740
79/11	.1330	-	-	.2100	-	.1750
79/12	.1300	.2080	-	.1910	.2380	.1680
No.Obs.	30.00	27.00	24.00	28.00	9.000	11.00
Mean	.1299	.1832	.3175	.1914	.2563	.1846
Median	.1300	.1860	.3080	.1910	.2540	.1780
S.D.M.	.0131	.0319	.0389	.0239	.0344	.0149
S.E.E.	.0105	.0169	.0261	.0226	.0248	.0103
C.V.	10.08	17.44	12.26	12.50	13.42	8.114
Slope	.0008	.0031	.0036	.0008	.0028	-.002
Y-Intercept	.1064	.1034	.2265	.1684	.1649	.2752
Coeff.Det.(r^2)	.3552	.7182	.5499	.1046	.4765	.5218
t (.01)	3.92 (1.64)	7.97 (1.70)	5.17 (1.71)	1.73 (1.70)	2.52 (1.83)	3.12 (1.79)
Range	.110 .172	.138 .234	.228 .386	.100 .238	.188 .314	.162 .212

Figure A-5.

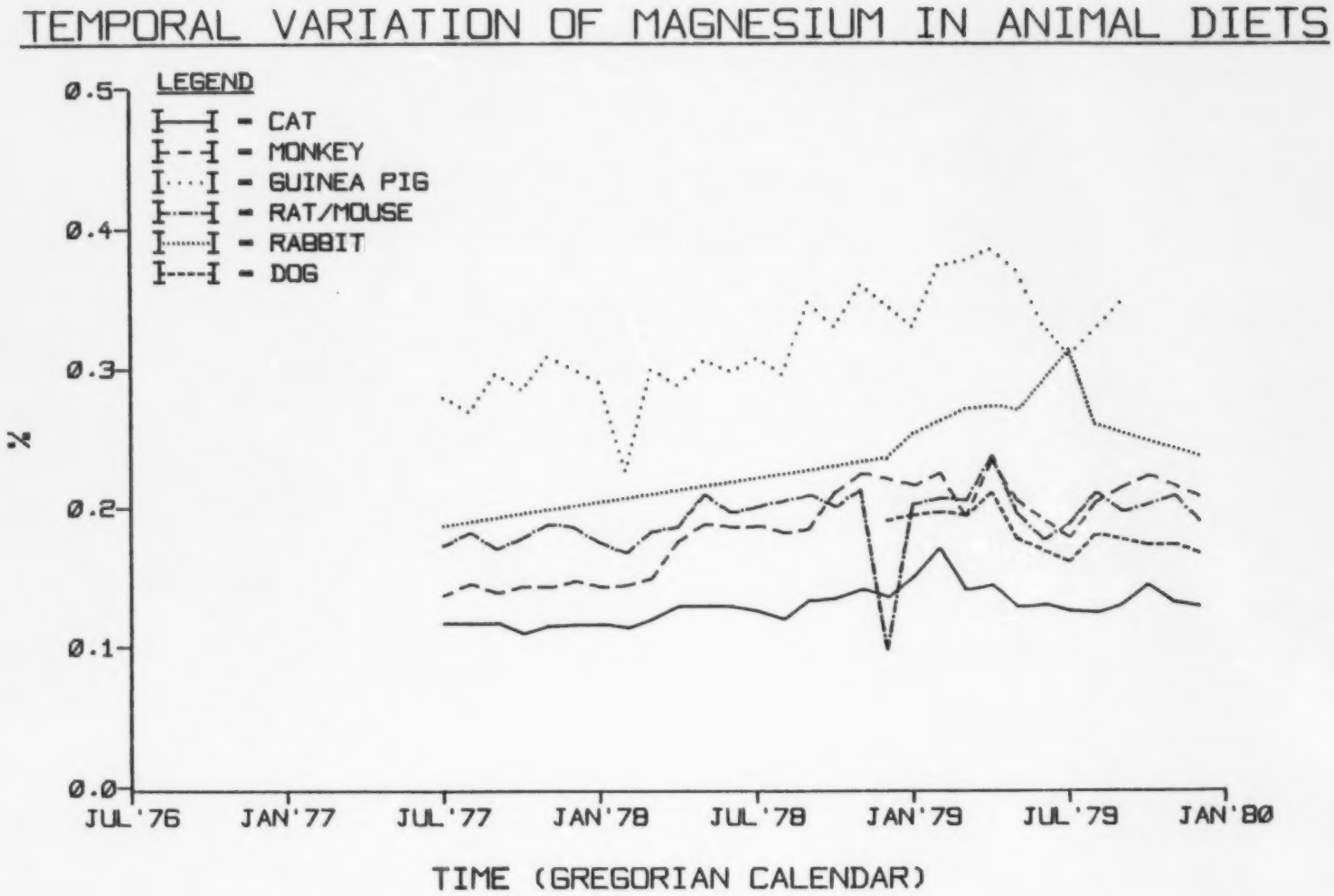
TEMPORAL VARIATION OF MAGNESIUM IN ANIMAL DIETS
LEGEND
I—I - CAT
I- -I - MONKEY
I····I - GUINEA PIG
I-·-I - RAT/MOUSE
I·····I - RABBIT
I----I - DOG
0.5
0.4
0.3
0.2
0.1
0.0
%
JUL'76
JAN'77
JUL'77
JAN'78
JUL'78
JAN'79
JUL'79
JAN'80
TIME (GREGORIAN CALENDAR)

Table A-6. Aluminum (mcg/g)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	-	-	-	-	-	-
76/09	-	-	-	-	-	-
76/10	-	-	-	-	-	-
76/11	-	-	-	-	-	-
76/12	-	-	-	-	-	-
77/01	-	-	-	-	-	-
77/02	-	-	-	-	-	-
77/03	-	-	-	-	-	-
77/04	-	-	-	-	-	-
77/05	-	-	-	-	-	-
77/06	-	-	-	-	-	-
77/07	89.70	112.0	244.0	165.0	186.0	-
77/08	115.0	117.0	246.0	184.0	-	-
77/09	115.0	105.0	217.0	118.0	-	-
77/10	89.50	94.00	222.0	145.0	-	-
77/11	95.40	112.0	219.0	136.0	-	-
77/12	110.0	120.0	-	172.0	-	-
78/01	149.0	123.0	210.0	175.0	-	-
78/02	131.0	120.0	255.0	168.0	-	-
78/03	164.0	162.0	230.0	192.0	-	-
78/04	171.0	106.0	235.5	164.0	-	-
78/05	179.6	129.0	219.8	213.6	-	-
78/06	116.4	101.3	194.8	310.0	-	-
78/07	116.3	118.6	222.8	208.8	-	-
78/08	100.8	117.2	215.9	-	-	-
78/09	143.8	119.3	242.4	196.6	-	-
78/10	128.0	117.6	256.0	228.0	-	-
78/11	65.18	113.3	179.8	161.3	-	-
78/12	66.09	-	-	188.6	169.4	87.90
79/01	85.64	101.4	185.2	205.4	193.8	50.78
79/02	89.16	97.15	175.4	196.3	-	39.09
79/03	60.32	156.5	199.1	210.3	176.1	46.96
79/04	66.20	84.40	207.8	167.0	175.1	53.27
79/05	56.26	79.99	209.1	177.8	150.7	47.28
79/06	75.78	-	137.8	117.6	-	-
79/07	89.93	86.78	222.4	219.5	216.6	67.53
79/08	131.7	122.3	-	226.2	187.3	130.0
79/09	102.4	95.00	157.8	163.7	-	-
79/10	96.05	119.4	-	-	-	39.74
79/11	116.6	-	-	222.3	-	73.20
79/12	96.43	101.1	-	171.5	152.4	88.48
No.Obs.	30.00	27.00	24.00	28.00	9.000	11.00
Mean	107.0	112.2	212.6	185.8	178.6	65.83
Median	100.8	112.0	217.0	177.8	175.1	50.78
S.D.M.	32.52	18.65	29.67	38.73	20.53	27.66
S.E.E.	30.46	-	23.44	-	-	-
C.V.	30.37	16.61	13.95	20.84	11.49	42.02
Slope	-1.29	-	-2.32	-	-	-
Y-Intercept	141.3	-	269.9	-	-	-
Coeff.Det.(r^2)	.1226	-	.3758	-	-	-
t (.01)	1.97 (1.64)	( )	3.63 (1.71)	( )	( )	( )
Range	56.2 179.	79.9 162.	137. 256.	117. 310.	150. 216.	39.0 130.

Figure A-6.

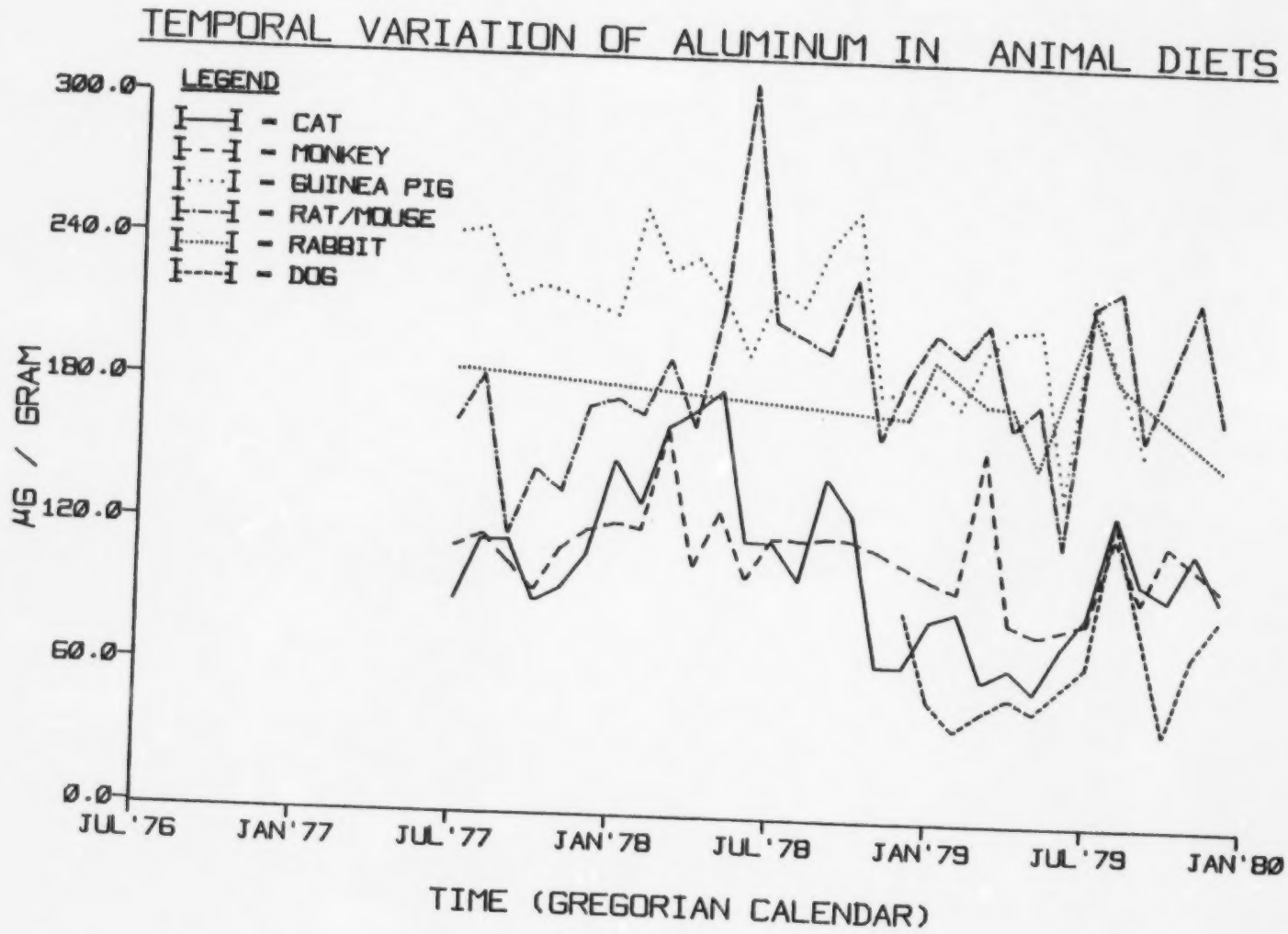
TEMPORAL VARIATION OF ALUMINUM IN ANIMAL DIETS
LEGEND
I—I - CAT
I--I - MONKEY
I····I - GUINEA PIG
I-·-I - RAT/MOUSE
I·····I - RABBIT
I----I - DOG
300.0
240.0
180.0
120.0
60.0
0.0
UG / GRAM
JUL'76
JAN'77
JUL'77
JAN'78
JUL'78
JAN'79
JUL'79
JAN'80
TIME (GREGORIAN CALENDAR)

Table A-7. Barium (mcg/g)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	-	-	-	-	-	-
76/09	-	-	-	-	-	-
76/10	-	-	-	-	-	-
76/11	-	-	-	-	-	-
76/12	-	-	-	-	-	-
77/01	-	-	-	-	-	-
77/02	-	-	-	-	-	-
77/03	-	-	-	-	-	-
77/04	-	-	-	-	-	-
77/05	-	-	-	-	-	-
77/06	-	-	-	-	-	-
77/07	4.290	1.600	21.60	16.20	23.00	-
77/08	4.330	3.290	23.70	16.10	-	-
77/09	4.360	3.110	13.50	10.50	-	-
77/10	4.020	2.850	18.00	12.80	-	-
77/11	4.040	3.890	16.40	10.60	-	-
77/12	4.470	2.750	-	7.930	-	-
78/01	4.610	1.810	19.50	8.390	-	-
78/02	4.460	3.340	16.80	7.950	-	-
78/03	5.020	2.740	11.20	10.00	-	-
78/04	4.660	4.350	10.30	9.185	-	-
78/05	-	-	-	-	-	-
78/06	4.850	5.410	15.47	13.11	-	-
78/07	3.930	7.210	12.20	12.88	-	-
78/08	3.940	6.430	18.24	-	-	-
78/09	4.230	6.320	20.62	16.62	-	-
78/10	4.350	8.420	18.11	14.06	-	-
78/11	3.450	6.690	19.90	11.42	-	-
78/12	3.520	-	-	12.30	24.47	11.49
79/01	2.890	6.920	17.04	16.05	22.80	8.800
79/02	3.660	10.80	28.60	17.10	-	15.28
79/03	2.660	9.370	24.19	15.11	21.28	12.68
79/04	2.880	9.100	31.58	18.52	21.74	15.71
79/05	2.460	8.360	21.30	11.50	16.88	8.900
79/06	3.770	-	12.22	11.41	-	-
79/07	3.120	7.940	27.40	14.32	27.82	10.64
79/08	3.520	10.74	-	14.46	25.09	10.84
79/09	2.880	9.350	15.32	11.00	-	-
79/10	2.780	8.430	-	-	-	9.830
79/11	2.840	-	-	14.16	-	17.12
79/12	3.120	10.06	-	14.77	15.33	9.320
No.Obs.	29.00	26.00	23.00	27.00	9.000	11.00
Mean	3.762	6.203	18.83	12.90	22.04	11.87
Median	3.770	6.430	18.00	12.80	21.74	10.64
S.D.M.	.7342	2.936	5.591	2.929	3.912	2.936
S.E.E.	.4530	1.186	-	2.758	-	-
C.V.	19.51	47.34	29.68	22.69	17.74	24.72
Slope	-.064	.3040	-	.1103	-	-
Y-Intercept	5.489	-1.62	-	10.00	-	-
Coeff.Det.(r↑2)	.6194	.8368	-	.1128	-	-
t (.01)	6.62 (1.69)	11.0 (1.70)	( )	1.77 (1.70)	( )	( )
Range	2.46 5.02	1.60 10.8	10.3 31.5	7.93 18.5	15.3 27.8	8.80 17.1

Figure A-7.

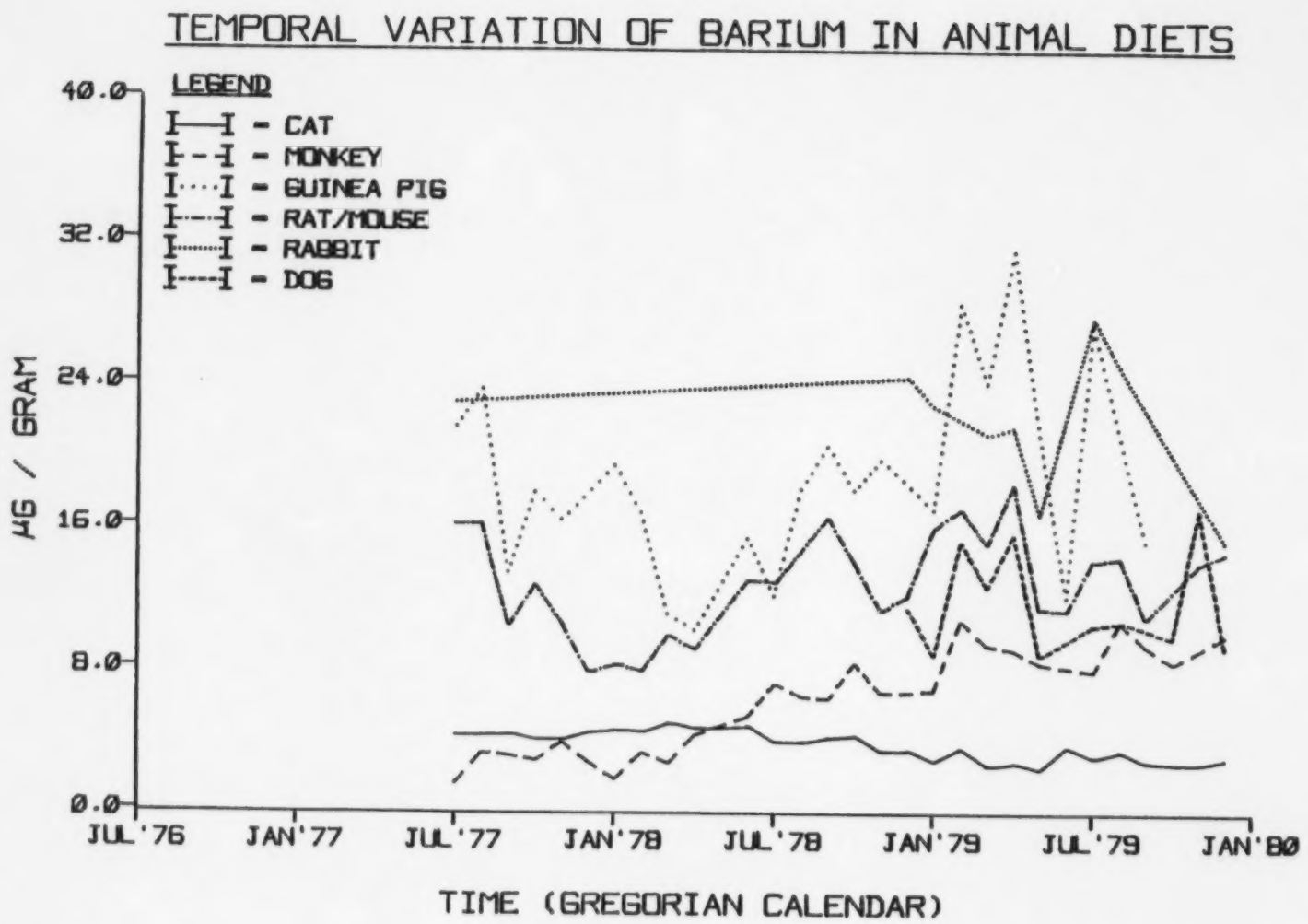
TEMPORAL VARIATION OF BARIUM IN ANIMAL DIETS
LEGEND
I—I - CAT
I--I - MONKEY
I····I - GUINEA PIG
I-·-I - RAT/MOUSE
I·····I - RABBIT
I----I - DOG
40.0
32.0
24.0
16.0
8.0
0.0
µG / GRAM
JUL '76
JAN '77
JUL '77
JAN '78
JUL '78
JAN '79
JUL '79
JAN '80
TIME (GREGORIAN CALENDAR)

Table A-8. Iron (mcg/g)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	-	-	-	-	-	-
76/09	-	-	-	-	-	-
76/10	-	-	-	-	-	-
76/11	-	-	-	-	-	-
76/12	-	-	-	-	-	-
77/01	-	-	-	-	-	-
77/02	-	-	-	-	-	-
77/03	-	-	-	-	-	-
77/04	-	-	-	-	-	-
77/05	-	-	-	-	-	-
77/06	-	-	-	-	-	-
77/07	724.0	374.0	330.0	314.0	284.0	-
77/08	696.0	435.0	343.0	387.0	-	-
77/09	671.0	344.0	386.0	301.0	-	-
77/10	693.0	295.0	374.0	340.0	-	-
77/11	729.0	406.0	418.0	351.0	-	-
77/12	791.0	415.0	-	2.990	-	-
78/01	786.0	376.0	336.0	276.0	-	-
78/02	747.0	375.0	307.0	258.0	-	-
78/03	828.0	348.0	298.0	253.0	-	-
78/04	749.5	403.0	372.0	277.0	-	-
78/05	1006	500.6	373.2	370.0	-	-
78/06	809.0	422.2	331.4	355.0	-	-
78/07	-	517.6	330.1	591.0	-	-
78/08	874.4	442.0	377.8	-	-	-
78/09	1056	448.2	396.8	369.2	-	-
78/10	1032	506.6	414.9	373.0	-	-
78/11	915.2	478.0	313.9	303.3	-	-
78/12	822.8	-	-	345.2	279.4	552.3
79/01	826.4	458.8	353.8	449.6	337.4	272.9
79/02	1200	419.9	265.8	304.2	-	308.2
79/03	917.8	615.0	315.0	283.0	301.2	314.7
79/04	959.6	397.6	293.4	266.0	346.2	310.0
79/05	893.0	252.4	363.6	380.2	270.4	291.8
79/06	809.2	-	290.2	215.8	-	-
79/07	1000	203.0	249.2	360.7	339.4	285.6
79/08	1050	420.9	-	314.8	280.2	267.2
79/09	866.7	380.6	248.8	249.3	-	-
79/10	835.6	417.7	-	-	-	253.7
79/11	873.0	-	-	344.0	-	323.2
79/12	724.8	426.0	-	269.5	252.8	261.2
No.Obs.	29.00	27.00	24.00	28.00	9.000	11.00
Mean	806.1	410.3	336.7	317.9	299.0	312.8
Median	826.4	415.0	331.4	314.0	280.2	285.6
S.D.M.	79.81	82.23	48.19	95.77	34.01	82.76
S.E.E.	61.45	-	41.17	-	-	70.33
C.V.	9.900	20.04	14.31	30.11	11.37	26.46
Slope	5.360	-	-3.19	-	-	-10.5
Y-Intercept	668.2	-	415.5	-	-	677.9
Coeff.Det.(r^2)	.4072	-	.2698	-	-	.2779
t (.01)	5.09 (1.69)	( )	2.84 (1.71)	( )	( )	1.85 (1.79)
Range	671. 1200	203. 615.	248. 418.	2.99 591.	252. 346.	253. 552.

Figure A-8.

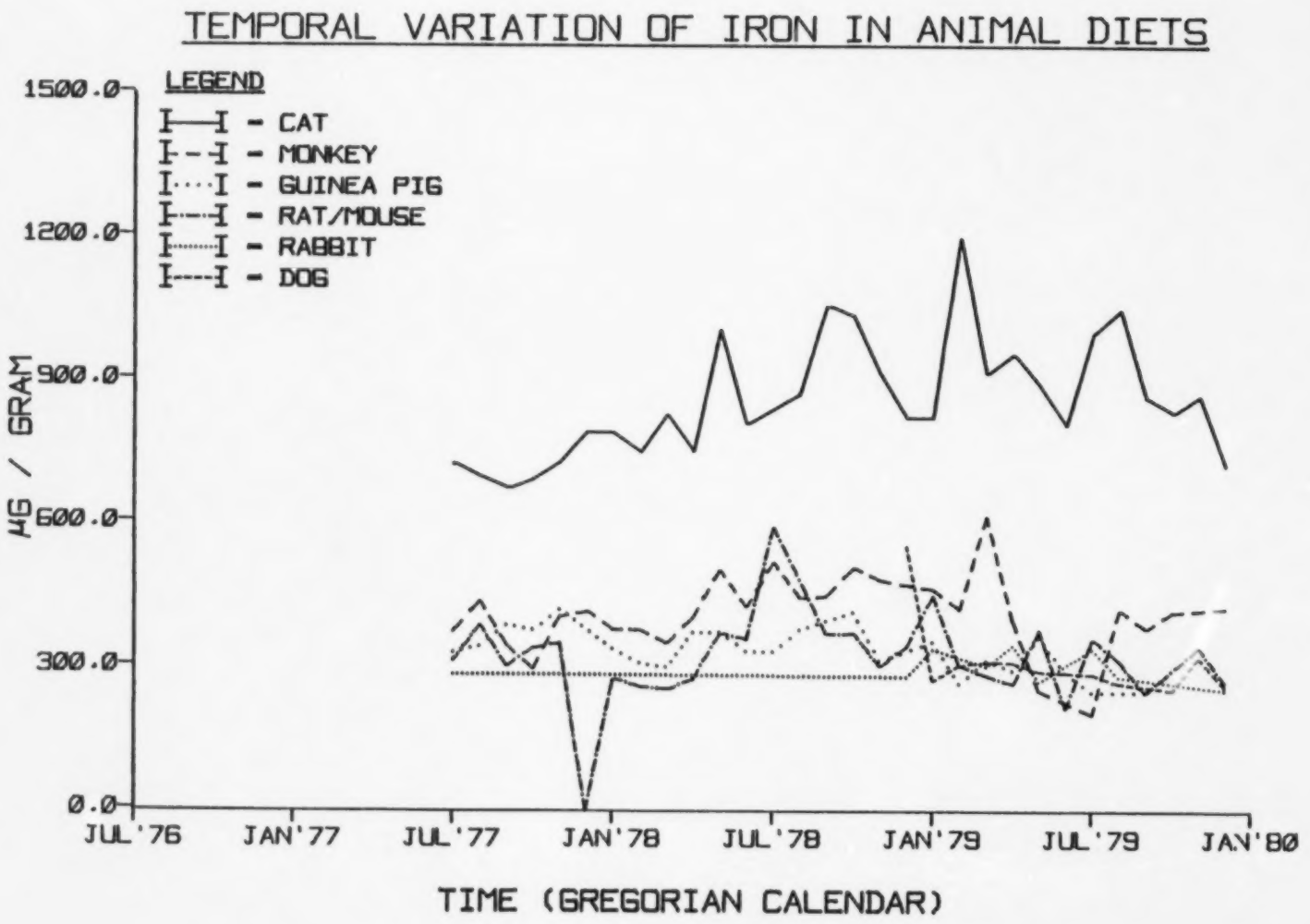
TEMPORAL VARIATION OF IRON IN ANIMAL DIETS
LEGEND
I—I - CAT
I--I - MONKEY
I····I - GUINEA PIG
I-·-I - RAT/MOUSE
I·····I - RABBIT
I----I - DOG
1500.0
1200.0
900.0
600.0
300.0
0.0
MG / GRAM
JUL'76
JAN'77
JUL'77
JAN'78
JUL'78
JAN'79
JUL'79
JAN'80
TIME (GREGORIAN CALENDAR)

Table A-9. Strontium (mcg/g)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	-	-	-	-	-	-
76/09	-	-	-	-	-	-
76/10	-	-	-	-	-	-
76/11	-	-	-	-	-	-
76/12	-	-	-	-	-	-
77/01	-	-	-	-	-	-
77/02	-	-	-	-	-	-
77/03	-	-	-	-	-	-
77/04	-	-	-	-	-	-
77/05	-	-	-	-	-	-
77/06	-	-	-	-	-	-
77/07	23.00	13.00	41.80	29.80	37.60	-
77/08	24.20	13.70	43.50	31.70	-	-
77/09	25.80	11.80	39.40	21.80	-	-
77/10	20.70	10.50	38.70	26.40	-	-
77/11	21.40	12.70	42.70	26.70	-	-
77/12	23.10	12.30	-	26.70	-	-
78/01	28.40	13.10	34.40	24.20	-	-
78/02	27.80	13.80	32.60	18.20	-	-
78/03	25.80	10.80	29.80	21.60	-	-
78/04	33.55	12.30	30.00	24.85	-	-
78/05	25.27	11.52	24.58	23.14	-	-
78/06	17.78	4.850	16.87	16.00	-	-
78/07	11.84	3.500	16.45	12.33	-	-
78/08	11.46	2.980	16.88	-	-	-
78/09	12.32	3.340	20.78	13.95	-	-
78/10	12.56	5.280	21.64	13.62	-	-
78/11	3.860	4.670	23.38	11.98	-	-
78/12	3.560	-	-	12.70	28.50	2.590
79/01	10.10	11.32	37.12	23.33	32.93	10.97
79/02	10.36	13.02	30.35	19.96	-	18.32
79/03	12.51	15.10	26.10	22.09	32.98	16.76
79/04	13.46	11.90	32.80	23.74	28.10	20.96
79/05	11.66	10.92	23.96	22.26	22.46	11.68
79/06	12.80	-	21.13	17.70	-	-
79/07	16.98	10.84	28.76	22.23	30.16	14.06
79/08	15.76	12.76	-	21.51	32.20	14.86
79/09	12.38	12.50	23.24	18.49	-	-
79/10	14.30	13.54	-	-	-	10.58
79/11	13.12	-	-	21.50	-	10.50
79/12	10.08	12.85	-	18.68	26.22	10.96
No.Obs.	30.00	27.00	24.00	28.00	9.000	11.00
Mean	16.86	10.55	29.03	20.97	30.12	12.93
Median	13.46	11.80	28.76	21.60	28.50	10.97
S.D.M.	7.469	3.682	8.452	5.165	4.429	4.907
S.E.E.	5.574	-	6.919	4.668	3.322	-
C.V.	44.29	34.89	29.10	24.63	14.70	37.95
Slope	-.564	-	-.619	-.251	-.357	-
Y-Intercept	31.82	-	44.32	27.54	41.39	-
Coeff.Det.(r^2)	.4430	-	.3298	.1832	.4373	-
t (.01)	4.71 (1.64)	( )	3.28 (1.71)	2.41 (1.70)	2.33 (1.83)	( )
Range	3.56 33.5	2.98 15.1	16.4 43.5	11.9 31.7	22.4 37.6	2.59 20.9

Figure A-9.

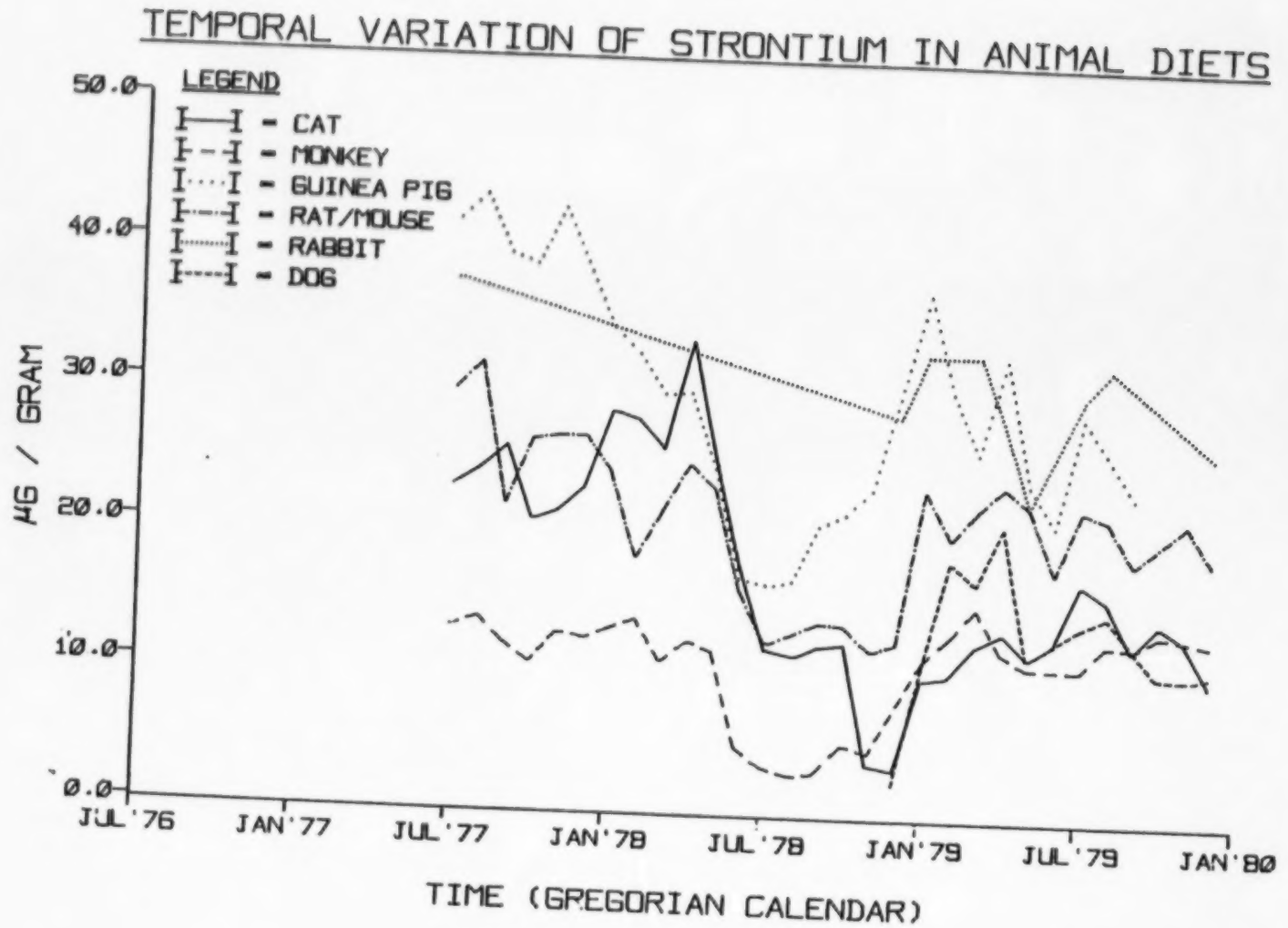
TEMPORAL VARIATION OF STRONTIUM IN ANIMAL DIETS
LEGEND
CAT
MONKEY
GUINEA PIG
RAT/MOUSE
RABBIT
DOG
50.0
40.0
30.0
20.0
10.0
0.0
UG / GRAM
JUL '76
JAN '77
JUL '77
JAN '78
JUL '78
JAN '79
JUL '79
JAN '80
TIME (GREGORIAN CALENDAR)

Table A-10. Boron (mcg/g)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	-	-	-	-	-	-
76/09	-	-	-	-	-	-
76/10	-	-	-	-	-	-
76/11	-	-	-	-	-	-
76/12	-	-	-	-	-	-
77/01	-	-	-	-	-	-
77/02	-	-	-	-	-	-
77/03	-	-	-	-	-	-
77/04	-	-	-	-	-	-
77/05	-	-	-	-	-	-
77/06	-	-	-	-	-	-
77/07	12.40	14.40	18.40	14.00	14.80	-
77/08	11.70	15.60	20.60	15.20	-	-
77/09	11.70	15.10	20.50	14.70	-	-
77/10	11.60	14.00	17.80	14.40	-	-
77/11	12.20	14.50	21.30	15.10	-	-
77/12	12.20	15.60	-	14.20	-	-
78/01	14.20	15.30	18.60	14.20	-	-
78/02	13.40	16.80	16.80	13.40	-	-
78/03	15.40	14.60	17.10	15.60	-	-
78/04	17.15	15.30	18.75	15.05	-	-
78/05	9.070	10.14	15.76	11.34	-	-
78/06	8.200	11.66	15.11	11.85	-	-
78/07	6.560	11.28	15.80	11.34	-	-
78/08	6.480	11.34	16.74	-	-	-
78/09	9.030	11.21	17.84	11.71	-	-
78/10	29.94	21.34	19.66	17.95	-	-
78/11	8.300	12.64	16.40	11.76	-	-
78/12	7.370	-	-	11.70	14.85	8.280
79/01	8.950	11.58	16.16	13.12	16.00	7.920
79/02	8.270	12.92	17.68	12.99	-	8.160
79/03	6.850	10.65	15.87	11.50	14.57	6.640
79/04	10.29	14.04	20.80	16.27	18.76	9.800
79/05	8.600	12.18	17.30	12.68	16.37	7.780
79/06	5.430	-	11.11	9.570	-	-
79/07	5.910	7.120	15.67	12.20	15.98	6.720
79/08	4.400	8.820	-	10.14	13.52	6.230
79/09	1.960	5.850	10.98	7.840	-	-
79/10	16.08	14.56	-	-	-	14.36
79/11	7.640	-	-	16.55	-	12.34
79/12	4.780	7.930	-	11.00	11.32	5.200
No.Obs.	30.00	27.00	24.00	28.00	9.000	11.00
Mean	10.20	12.83	17.19	13.12	15.13	8.493
Median	8.950	12.64	17.10	12.99	14.80	7.780
S.D.M.	5.213	3.276	2.599	2.291	2.055	2.728
S.E.E.	4.748	2.656	2.099	2.061	-	-
C.V.	51.10	25.53	15.11	17.46	13.58	32.12
Slope	-.244	-.220	-.195	-.113	-	-
Y-Intercept	16.67	18.48	22.02	16.09	-	-
Coeff.Det.(r^2)	.1702	.3428	.3476	.1910	-	-
t (.01)	2.39 (1.64)	3.60 (1.70)	3.41 (1.71)	2.47 (1.70)	( )	( )
Range	1.96 29.9	5.85 21.3	10.9 21.3	7.84 17.9	11.3 18.7	5.20 14.3

Figure A-10.

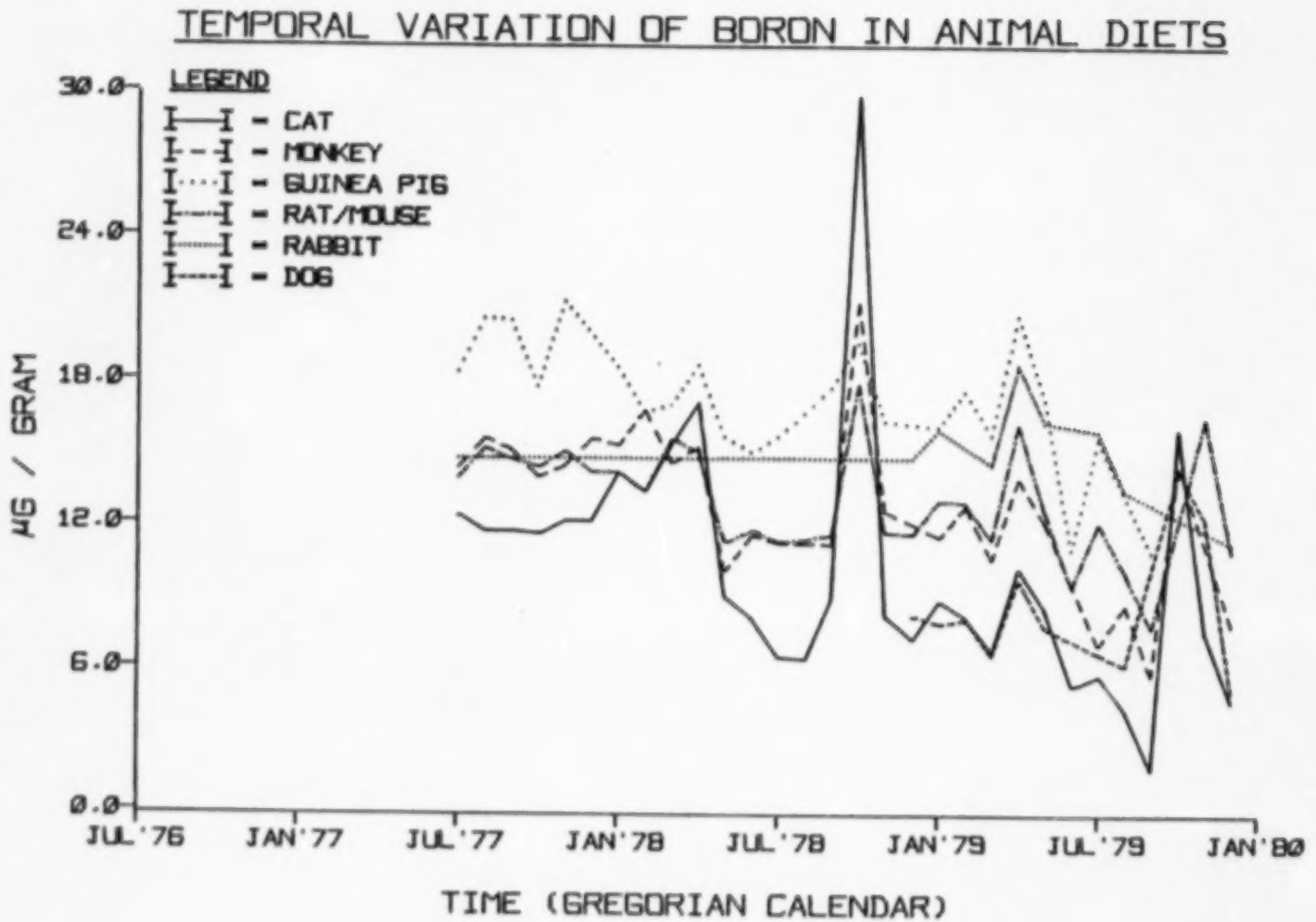
TEMPORAL VARIATION OF BORON IN ANIMAL DIETS
LEGEND
I—I - CAT
I--I - MONKEY
I····I - GUINEA PIG
I—·—I - RAT/MOUSE
I——I - RABBIT
I---I - DOG
30.0
24.0
18.0
12.0
6.0
0.0
MG / GRAM
JUL'76
JAN'77
JUL'77
JAN'78
JUL'78
JAN'79
JUL'79
JAN'80
TIME (GREGORIAN CALENDAR)

Table A-11. Copper (mcg/g)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	-	-	-	-	-	-
76/09	-	-	-	-	-	-
76/10	-	-	-	-	-	-
76/11	-	-	-	-	-	-
76/12	-	-	-	-	-	-
77/01	-	-	-	-	-	-
77/02	-	-	-	-	-	-
77/03	-	-	-	-	-	-
77/04	-	-	-	-	-	-
77/05	-	-	-	-	-	-
77/06	-	-	-	-	-	-
77/07	14.10	10.90	14.20	13.00	18.00	-
77/08	15.80	10.70	12.60	14.40	-	-
77/09	15.30	10.20	15.10	11.80	-	-
77/10	13.60	9.900	12.50	12.20	-	-
77/11	14.30	16.80	12.60	10.40	-	-
77/12	14.40	9.660	-	10.10	-	-
78/01	15.00	9.900	13.50	9.650	-	-
78/02	14.20	9.180	8.180	10.20	-	-
78/03	14.00	9.940	14.00	8.240	-	-
78/04	17.05	30.30	13.35	8.215	-	-
78/05	17.12	31.84	15.50	7.560	-	-
78/06	11.44	31.22	13.82	9.460	-	-
78/07	13.90	28.76	12.67	8.440	-	-
78/08	14.10	27.26	13.46	-	-	-
78/09	14.83	26.34	14.42	10.12	-	-
78/10	42.31	40.04	18.94	20.72	-	-
78/11	16.54	32.34	16.22	9.930	-	-
78/12	15.20	-	-	10.78	14.21	13.16
79/01	6.260	29.81	10.69	10.05	14.96	12.22
79/02	12.83	19.08	11.76	11.22	-	12.30
79/03	15.92	42.48	12.53	11.31	14.57	11.60
79/04	17.20	19.96	11.88	13.02	16.44	13.30
79/05	15.01	9.980	11.50	10.56	13.85	12.30
79/06	9.670	-	9.800	9.620	-	-
79/07	14.32	11.11	11.16	9.580	11.96	11.99
79/08	16.76	14.52	-	13.94	12.44	7.780
79/09	11.12	15.26	9.360	8.720	-	-
79/10	17.78	28.38	-	-	-	9.240
79/11	14.80	-	-	10.52	-	12.22
79/12	15.80	16.92	-	11.18	14.32	9.590
No.Obs.	30.00	27.00	24.00	28.00	9.000	11.00
Mean	15.35	20.47	12.90	10.89	14.52	11.42
Median	14.80	16.80	12.60	10.20	14.21	11.99
S.D.M.	5.620	10.39	2.314	2.559	1.852	1.763
S.E.E.	-	-	-	-	1.221	1.380
C.V.	36.60	50.76	17.93	23.50	12.75	15.43
Slope	-	-	-	-	-.169	-.264
Y-Intercept	-	-	-	-	19.88	20.60
Coeff.Det.(r*2)	-	-	-	-	.5650	.3871
t (.01)	( )	( )	( )	( )	3.01 (1.83)	2.38 (1.79)
Range	6.26 42.3	9.18 42.4	8.18 18.9	7.56 20.7	11.9 18.0	7.78 13.3

Figure A-11.

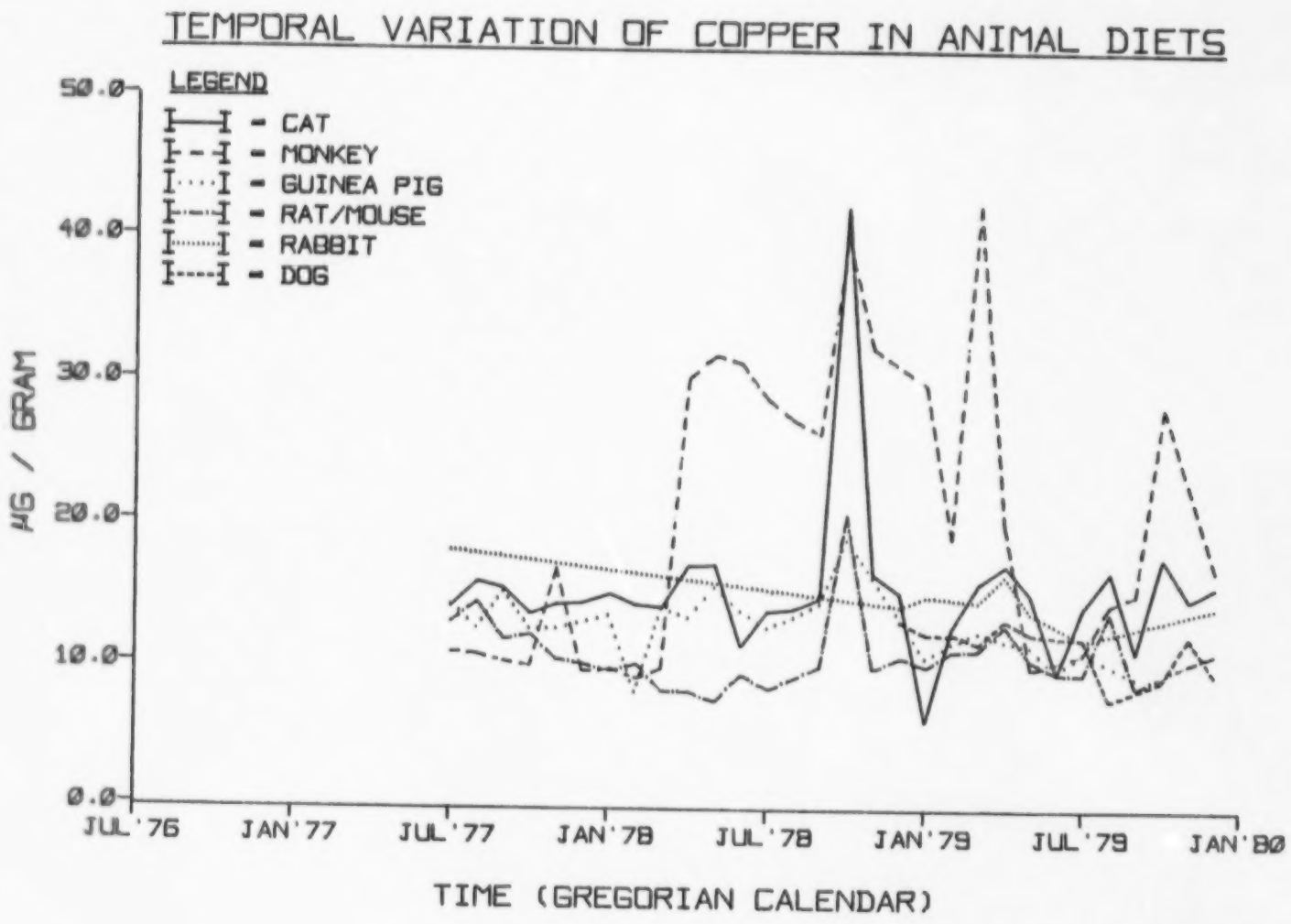
TEMPORAL VARIATION OF COPPER IN ANIMAL DIETS
LEGEND
CAT
MONKEY
GUINEA PIG
RAT/MOUSE
RABBIT
DOG
50.0
40.0
30.0
20.0
10.0
0.0
MG / GRAM
JUL '76
JAN '77
JUL '77
JAN '78
JUL '78
JAN '79
JUL '79
JAN '80
TIME (GREGORIAN CALENDAR)

Table A-12. Zinc (mcg/g)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	-	-	-	-	-	-
76/09	-	-	-	-	-	-
76/10	-	-	-	-	-	-
76/11	-	-	-	-	-	-
76/12	-	-	-	-	-	-
77/01	-	-	-	-	-	-
77/02	-	-	-	-	-	-
77/03	-	-	-	-	-	-
77/04	-	-	-	-	-	-
77/05	-	-	-	-	-	-
77/06	-	-	-	-	-	-
77/07	308.0	34.20	61.20	65.20	77.50	-
77/08	301.0	33.50	56.30	60.50	-	-
77/09	288.0	33.70	63.90	55.80	-	-
77/10	316.0	30.30	53.90	54.50	-	-
77/11	309.0	38.20	60.40	56.70	-	-
77/12	301.0	33.00	-	55.80	-	-
78/01	329.0	35.60	60.00	58.90	-	-
78/02	333.0	31.20	50.40	54.60	-	-
78/03	328.0	41.40	65.60	57.10	-	-
78/04	315.0	134.0	61.05	54.65	-	-
78/05	262.6	130.6	65.32	53.20	-	-
78/06	190.8	121.8	60.05	46.39	-	-
78/07	331.2	127.6	62.08	55.48	-	-
78/08	310.1	121.6	58.40	-	-	-
78/09	355.9	149.3	83.98	61.46	-	-
78/10	392.8	172.4	71.26	90.94	-	-
78/11	214.2	144.2	78.26	55.35	-	-
78/12	226.8	-	-	64.73	129.2	239.2
79/01	65.10	144.2	78.18	60.88	123.6	236.2
79/02	281.8	149.7	84.80	67.40	-	225.6
79/03	299.6	179.6	89.80	64.96	120.0	207.1
79/04	336.1	168.3	88.12	80.92	131.0	240.8
79/05	288.2	92.97	85.58	61.66	122.2	249.8
79/06	202.3	-	67.11	58.75	-	-
79/07	352.2	98.51	86.52	53.80	81.38	273.6
79/08	394.6	127.2	-	70.56	87.16	164.8
79/09	227.0	143.6	75.28	57.49	-	-
79/10	261.2	124.0	-	-	-	197.0
79/11	210.7	-	-	54.50	-	308.8
79/12	233.2	135.0	-	63.14	112.3	178.0
No.Obs.	30.00	27.00	24.00	28.00	9.000	11.00
Mean	285.4	102.8	69.47	60.54	109.3	229.1
Median	301.0	121.8	65.32	57.49	112.3	225.6
S.D.M.	67.83	52.53	12.10	8.895	21.33	41.62
S.E.E.	-	36.01	7.640	-	-	-
C.V.	23.76	51.10	17.42	14.69	19.50	18.16
Slope	-	4.399	1.199	-	-	-
Y-Intercept	-	-9.80	39.89	-	-	-
Coeff.Det.(r^2)	-	.5300	.6019	-	-	-
t (.01)	( )	5.30 (1.70)	5.75 (1.71)	( )	( )	( )
Range	65.1 394.	30.3 179.	50.4 89.8	46.3 90.9	77.5 131.	164. 308.

Figure A-12.

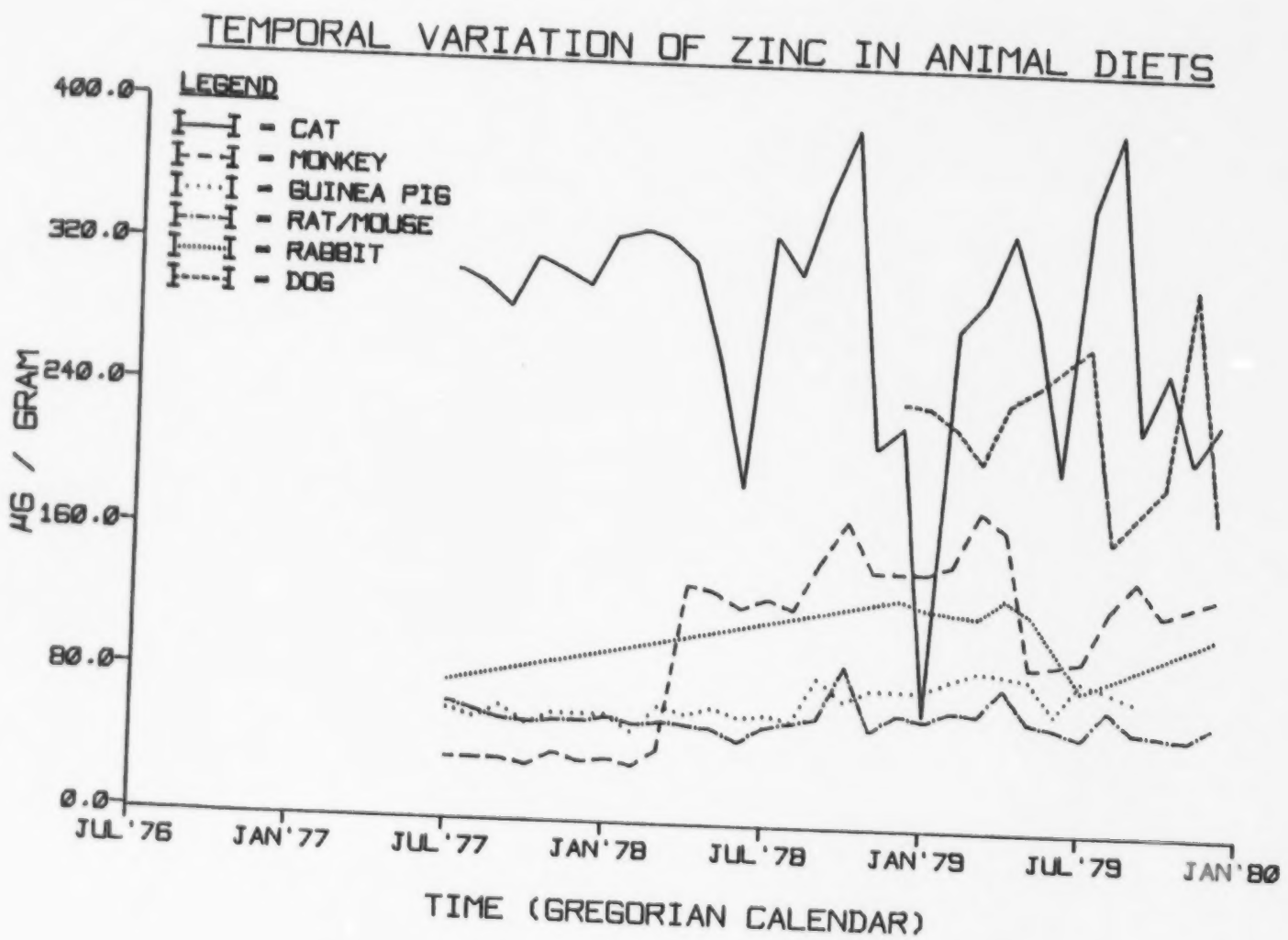
TEMPORAL VARIATION OF ZINC IN ANIMAL DIETS
LEGEND
I—I - CAT
I--I - MONKEY
I····I - GUINEA PIG
I-·-I - RAT/MOUSE
I·····I - RABBIT
I----I - DOG
400.0
320.0
240.0
160.0
80.0
0.0
UG / GRAM
JUL'76
JAN'77
JUL'77
JAN'78
JUL'78
JAN'79
JUL'79
JAN'80
TIME (GREGORIAN CALENDAR)

Table A-13. Manganese (mcg/g)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	65.70	42.90	59.90	60.80	-	-
76/09	65.00	52.00	71.80	66.40	-	-
76/10	60.70	50.90	65.20	59.80	-	-
76/11	74.65	53.23	78.79	74.44	90.77	-
76/12	68.69	55.48	65.85	62.19	95.32	-
77/01	71.20	53.63	81.28	64.34	86.79	-
77/02	76.70	49.84	80.16	68.05	83.01	-
77/03	65.75	55.25	65.85	78.78	93.73	-
77/04	69.68	45.68	75.47	68.00	93.78	-
77/05	71.84	50.21	75.00	122.3	89.67	-
77/06	65.04	49.01	70.83	71.25	89.65	-
77/07	66.30	46.80	77.10	65.40	85.60	-
77/08	66.37	49.70	65.66	70.31	-	-
77/09	65.54	53.96	73.06	66.46	-	-
77/10	66.97	46.25	66.04	65.20	-	-
77/11	67.50	156.1	75.26	69.28	-	-
77/12	63.16	48.21	-	59.20	-	-
78/01	75.16	52.37	78.72	61.77	-	-
78/02	68.55	47.36	60.95	59.33	-	-
78/03	73.45	50.41	70.24	61.98	-	-
78/04	66.05	101.2	63.27	60.81	-	-
78/05	65.69	105.6	66.52	69.66	-	-
78/06	56.91	101.9	67.65	62.55	-	-
78/07	71.29	100.8	68.17	68.47	-	-
78/08	68.61	100.3	65.74	59.50	-	-
78/09	72.94	95.58	65.39	83.62	-	-
78/10	125.7	121.6	68.24	90.51	-	-
78/11	67.26	112.6	81.26	64.63	-	-
78/12	56.27	-	-	63.33	85.88	47.15
79/01	20.53	101.9	62.71	63.53	92.23	57.60
79/02	70.35	98.49	72.56	63.31	-	52.06
79/03	55.53	124.2	65.72	57.18	85.24	50.19
79/04	55.18	95.36	69.78	63.24	88.72	54.48
79/05	54.96	47.04	67.90	57.07	86.76	51.75
79/06	46.54	-	79.87	57.31	-	-
79/07	81.20	76.78	71.55	58.89	74.97	66.93
79/08	-	-	-	-	-	-
79/09	-	-	-	-	-	-
79/10	-	-	-	-	-	-
79/11	-	-	-	-	-	-
79/12	-	-	-	-	-	-
No.Obs.	36.00	34.00	34.00	36.00	15.00	7.000
Mean	66.75	73.33	70.40	67.19	88.14	54.31
Median	66.37	53.63	68.24	63.53	86.79	51.75
S.D.M.	14.45	30.65	6.076	11.90	5.119	6.454
S.E.E.	14.28	24.41	6.055	11.61	4.474	4.784
C.V.	21.66	41.80	8.631	17.71	5.807	11.88
Slope	-.215	1.805	-.047	-.247	-.197	1.797
Y-Intercept	70.73	41.37	71.27	71.77	91.64	-3.47
Coeff.Det.(r†2)	.0246	.3657	.0070	.0479	.2358	.4506
t (.01)	2.74 (1.64)	2.74 (1.64)	2.74 (1.64)	2.74 (1.64)	2.74 (1.75)	2.74 (1.89)
Range	20.5 125.	42.9 156.	59.9 81.2	57.0 122.	74.9 95.3	47.1 66.9

Figure A-13.

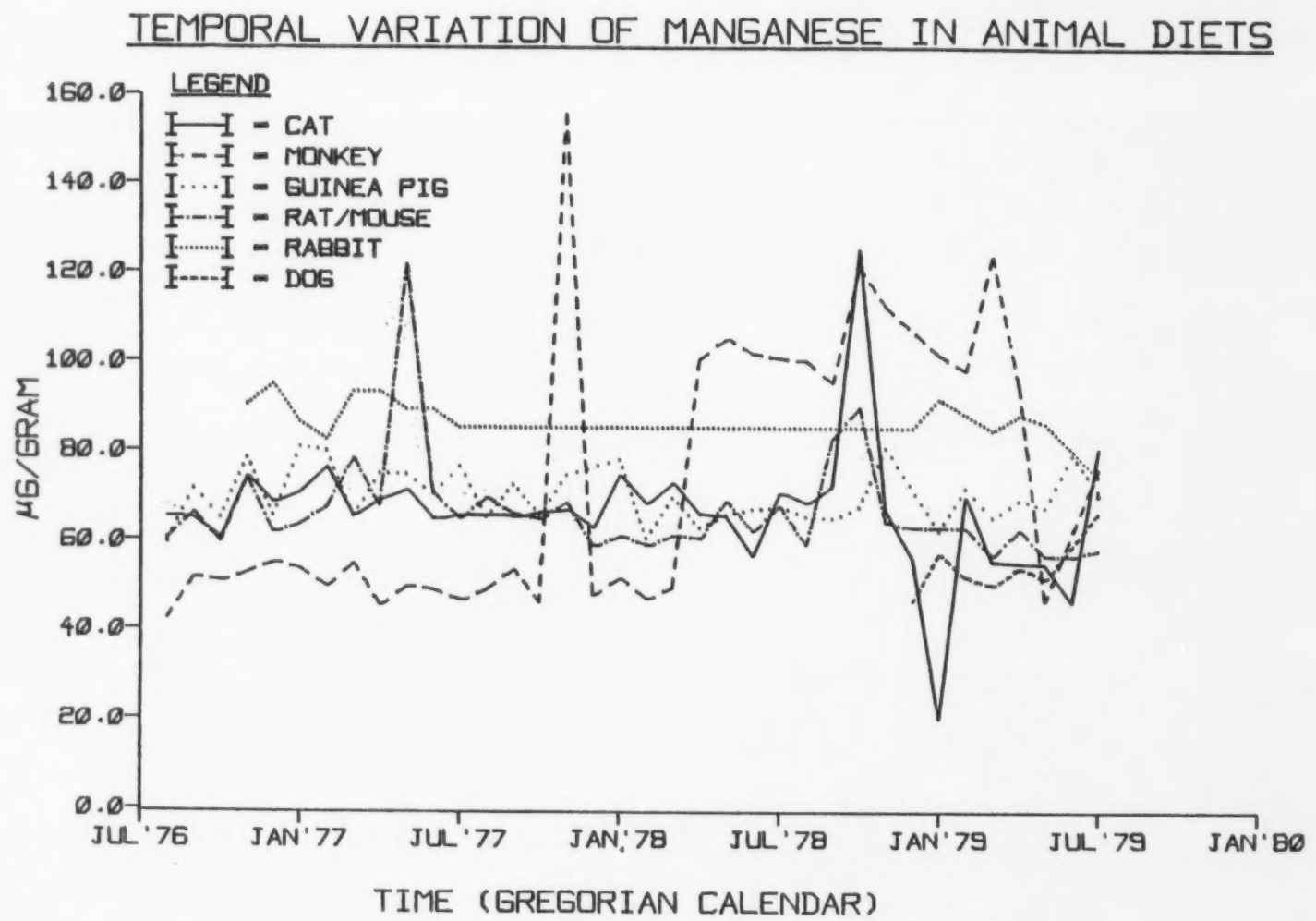
TEMPORAL VARIATION OF MANGANESE IN ANIMAL DIETS
LEGEND
I—I - CAT
I--I - MONKEY
I····I - GUINEA PIG
I-·-I - RAT/MOUSE
I·····I - RABBIT
I----I - DOG
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
MG/GRAM
JUL'76
JAN'77
JUL'77
JAN'78
JUL'78
JAN'79
JUL'79
JAN'80
TIME (GREGORIAN CALENDAR)

Table A-14. Chromium (mcg/g)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	-	-	-	-	-	-
76/09	-	-	-	-	-	-
76/10	-	-	-	-	-	-
76/11	-	-	-	-	-	-
76/12	-	-	-	-	-	-
77/01	-	-	-	-	-	-
77/02	-	-	-	-	-	-
77/03	-	-	-	-	-	-
77/04	-	-	-	-	-	-
77/05	-	-	-	-	-	-
77/06	-	-	-	-	-	-
77/07	3.660	2.730	2.590	2.110	1.840	-
77/08	4.050	3.790	3.670	3.810	-	-
77/09	4.220	2.890	4.110	2.870	-	-
77/10	2.590	2.620	2.760	2.630	-	-
77/11	2.760	2.010	3.260	2.050	-	-
77/12	4.520	3.280	-	3.320	-	-
78/01	4.380	3.220	3.280	3.450	-	-
78/02	2.700	2.480	2.380	2.180	-	-
78/03	4.260	2.900	3.080	3.640	-	-
78/04	4.415	2.140	3.170	2.575	-	-
78/05	1.680	.9600	1.230	1.340	-	-
78/06	1.400	1.020	1.490	1.180	-	-
78/07	1.280	.5500	1.600	1.350	-	-
78/08	1.360	1.050	1.750	-	-	-
78/09	1.560	1.200	2.060	1.370	-	-
78/10	1.590	1.790	1.910	1.640	-	-
78/11	.7900	.9100	1.420	1.160	-	-
78/12	1.130	-	-	1.520	1.460	1.220
79/01	.9800	1.120	1.820	1.440	1.460	.8900
79/02	.7600	3.010	3.960	3.400	-	1.180
79/03	1.050	1.410	4.730	4.450	1.320	1.310
79/04	.6600	2.840	4.650	3.480	2.100	1.240
79/05	1.120	1.670	2.970	2.460	2.750	1.320
79/06	1.340	-	1.720	4.400	-	-
79/07	1.260	1.020	2.280	1.870	1.620	.9600
79/08	1.520	4.660	-	4.370	1.330	1.420
79/09	1.070	1.620	2.740	2.660	-	-
79/10	6.100	2.180	-	-	-	1.650
79/11	5.310	-	-	2.520	-	10.72
79/12	2.230	1.680	-	4.110	3.220	1.420
No.Obs.	30.00	27.00	24.00	28.00	9.000	11.00
Mean	2.391	2.101	2.692	2.619	1.900	2.120
Median	1.560	1.790	2.590	2.520	1.460	1.240
S.D.M.	1.571	1.019	1.020	1.068	.6741	2.859
S.E.E.	1.488	-	-	-	-	-
C.V.	65.69	48.49	37.90	40.77	35.47	134.8
Slope	-.057	-	-	-	-	-
Y-Intercept	3.902	-	-	-	-	-
Coeff.Det.(r^2)	.1020	-	-	-	-	-
t (.01)	1.78 (1.64)	( )	( )	( )	( )	( )
Range	.660 6.10	.550 4.66	1.23 4.73	1.16 4.45	1.32 3.22	.890 10.7

Figure A-14.

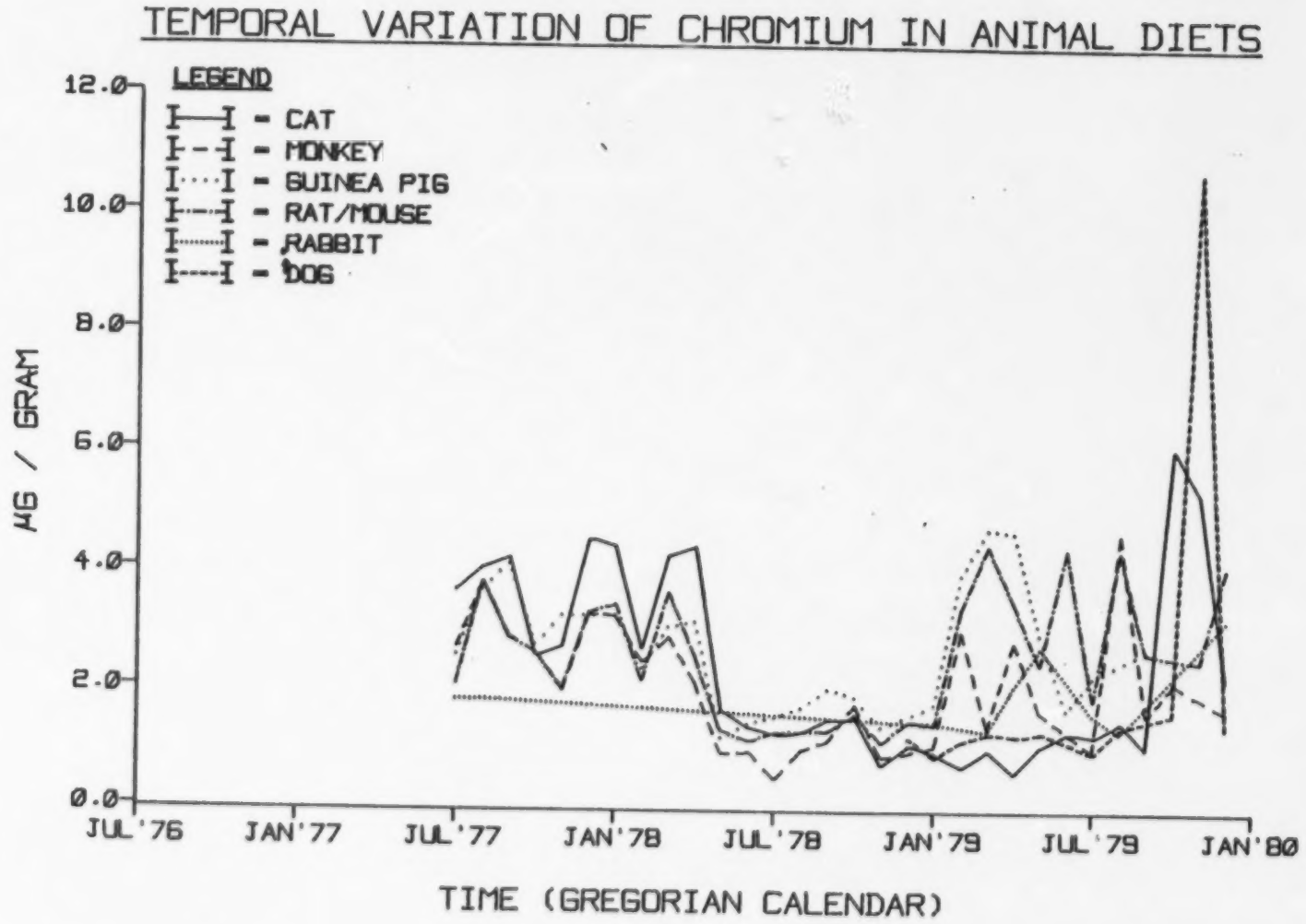
TEMPORAL VARIATION OF CHROMIUM IN ANIMAL DIETS
LEGEND
I—I - CAT
I--I - MONKEY
I····I - GUINEA PIG
I-·-I - RAT/MOUSE
I·····I - RABBIT
I----I - DOG
12.0
10.0
8.0
6.0
4.0
2.0
0.0
MG / GRAM
JUL'76
JAN'77
JUL'77
JAN'78
JUL'78
JAN'79
JUL'79
JAN'80
TIME (GREGORIAN CALENDAR)

Table A-15. Arsenic (mcg/g)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	.7000	0	.4000	.5000	-	-
76/09	.3800	.1200	.2000	.3400	-	-
76/10	.3800	.1600	.1200	.3680	-	-
76/11	.4891	.0760	.2717	.4239	.1956	-
76/12	.4623	.1612	.2688	.4193	.2043	-
77/01	.5777	.2333	.3000	.3555	.2666	-
77/02	.4622	.0754	.1698	.4056	.0943	-
77/03	.5098	.1274	.2450	.3431	.1568	-
77/04	.4574	.1276	.2234	.4468	.1489	-
77/05	.4018	.0841	.1495	.3644	.3925	-
77/06	.6326	.1020	.2346	.5204	.1836	-
77/07	.2909	.2181	.2424	.5818	.1696	-
77/08	.4578	.1325	.2289	.5662	-	-
77/09	.3265	.1122	.2040	.2959	-	-
77/10	.3404	0	.1489	.3617	-	-
77/11	.1098	.1098	.1758	.3736	-	-
77/12	.3333	0	-	.3571	-	-
78/01	.2268	0	.1443	.3092	-	-
78/02	.1882	0	.1411	.3764	-	-
78/03	.2352	.1647	.2235	.4705	-	-
78/04	.1707	0	.1524	.4451	-	-
78/05	.3043	0	.1304	.3043	-	-
78/06	.2470	0	.1176	.3764	-	-
78/07	.5232	0	.1395	.3720	-	-
78/08	.4891	.1086	0	.3913	-	-
78/09	.2941	0	0	.4941	-	-
78/10	.3452	0	.1547	.4940	-	-
78/11	.1970	.1250	.1100	.2900	-	-
78/12	.1686	-	-	.1686	0	.1204
79/01	.2848	.2088	.1645	.4050	0	.1392
79/02	.3350	.1350	.1900	.4950	-	0
79/03	.2037	0	.2312	.4312	0	0
79/04	.3181	.2272	.2840	.3579	.1818	.1704
79/05	.2094	0	.1418	.3310	0	.1486
79/06	.3680	-	.1903	.4505	-	-
79/07	.7192	0	.1637	.4502	.1461	0
79/08	.4114	.1942	-	.3885	.1257	0
79/09	.5625	.2000	.1687	.4375	-	-
79/10	.2666	0	-	-	-	0
79/11	.2787	-	-	.2363	-	0
79/12	.3020	.1145	-	.1927	0	0
No.Obs.	41.00	38.00	35.00	40.00	17.00	11.00
Mean	.3648	.0873	.1837	.3920	.1332	.0526
Median	.3333	.1020	.1687	.3764	.1461	0
S.D.M.	.1466	.0806	.0767	.0898	.1093	.0738
S.E.E.	.1391	.0802	.0697	.0873	.0844	.0606
C.V.	40.17	92.40	41.75	22.92	82.07	140.4
Slope	-.003	-.000	-.002	-.001	-.005	-.010
Y-Intercept	.4455	.1014	.2379	.4291	.2354	.4055
Coeff.Det.(r†2)	.0984	.0106	.1726	.0558	.4034	.3260
t (.01)	3.19 (1.64)	3.19 (1.64)	3.19 (1.64)	3.19 (1.64)	3.19 (1.74)	3.19 (1.79)
Range	.109 .719	0 .233	0 .400	.168 .581	0 .392	0 .170

Figure A-15.

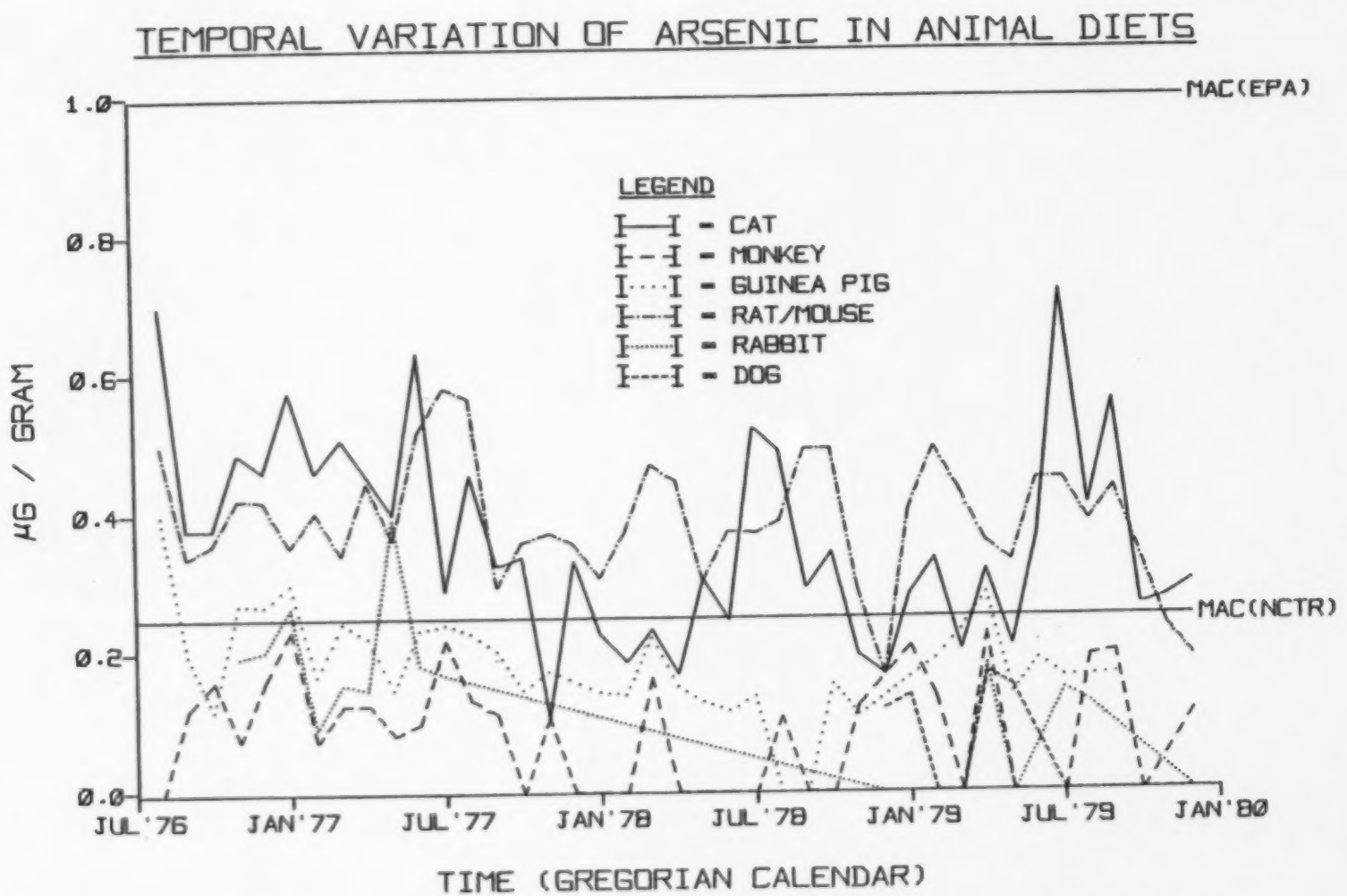
TEMPORAL VARIATION OF ARSENIC IN ANIMAL DIETS
MAC(EPA)
MAC(NCTR)
LEGEND
CAT
MONKEY
GUINEA PIG
RAT/MOUSE
RABBIT
DOG
1.0
0.8
0.6
0.4
0.2
0.0
MG / GRAM
JUL'76
JAN'77
JUL'77
JAN'78
JUL'78
JAN'79
JUL'79
JAN'80
TIME (GREGORIAN CALENDAR)

Table A-16. Cadmium (mcg/g)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	.1000	.0700	.1200	.0900	-	-
76/09	.1300	.0800	.1200	.1000	-	-
76/10	.1200	.0700	.1000	.0900	-	-
76/11	.1222	.0888	.1222	.0888	.1111	-
76/12	.1250	.1022	.1250	.1136	.1136	-
77/01	.1157	.0947	.1473	.1052	.1263	-
77/02	.1413	.1086	.1847	.1521	.1304	-
77/03	.2000	.1444	.1888	.1555	.1333	-
77/04	.2181	.1818	.2424	.1818	.1818	-
77/05	.1538	.1057	.1634	.1057	.1057	-
77/06	.1832	.1145	.1947	.1260	.1374	-
77/07	.0913	.1015	.1421	.1015	.1116	-
77/08	.1728	.0987	.1975	.1111	-	-
77/09	.1554	.1139	.1554	.1450	-	-
77/10	.1750	.1250	.2000	.1500	-	-
77/11	.1028	.1028	.1942	.1371	-	-
77/12	.1142	.0952	-	.0952	-	-
78/01	.3672	.1977	.2259	.1553	-	-
78/02	.2872	.1276	.1595	.1382	-	-
78/03	.3209	.1481	.1728	.1851	-	-
78/04	.3908	.1321	.1666	.1436	-	-
78/05	.3736	.1538	.1978	.2637	-	-
78/06	.1797	.1123	.1910	.1235	-	-
78/07	.2857	.1298	.1428	.1688	-	-
78/08	.2610	.1305	.1305	.1305	-	-
78/09	.3443	.1377	.1652	.1652	-	-
78/10	.4791	.1805	.1805	.2152	-	-
78/11	.1959	.1283	.1891	.1756	-	-
78/12	.1377	-	-	.1581	.1530	.0663
79/01	.1400	.1000	.1600	.1300	.1350	.1200
79/02	.2272	.1590	.1931	.1704	-	.1193
79/03	.1898	.1544	.2544	.2417	.1556	1.305
79/04	.1479	.1224	.1989	.1377	.1275	.1020
79/05	.1503	.1102	.1603	.1452	.1152	.0601
79/06	.1263	-	.1368	.2631	-	-
79/07	.1385	.9638	.1686	.1445	.1445	.0602
79/08	.1363	.2840	-	.2045	.1477	.0681
79/09	.1280	.1707	.2256	.2439	-	-
79/10	.1980	.1138	-	-	-	.0495
79/11	.1034	-	-	.1551	-	0
79/12	.2654	.1327	-	.2046	.2876	.0940
No.Obs.	41.00	38.00	35.00	40.00	17.00	11.00
Mean	.1950	.1496	.1719	.1528	.1421	.1858
Median	.1538	.1224	.1666	.1450	.1304	.0663
S.D.M.	.0935	.1413	.0361	.0467	.0422	.3727
S.E.E.	-	-	-	-	-	-
C.V.	47.95	94.42	21.03	30.57	29.72	200.5
Slope	-	-	-	-	-	-
Y-Intercept	-	-	-	-	-	-
Coeff.Det.(r^2)	-	-	-	-	-	-
t (.01)	( )	( )	( )	( )	( )	( )
Range	.091 .479	.070 .963	.100 .254	.088 .263	.105 .287	0 1.30

Figure A-16.

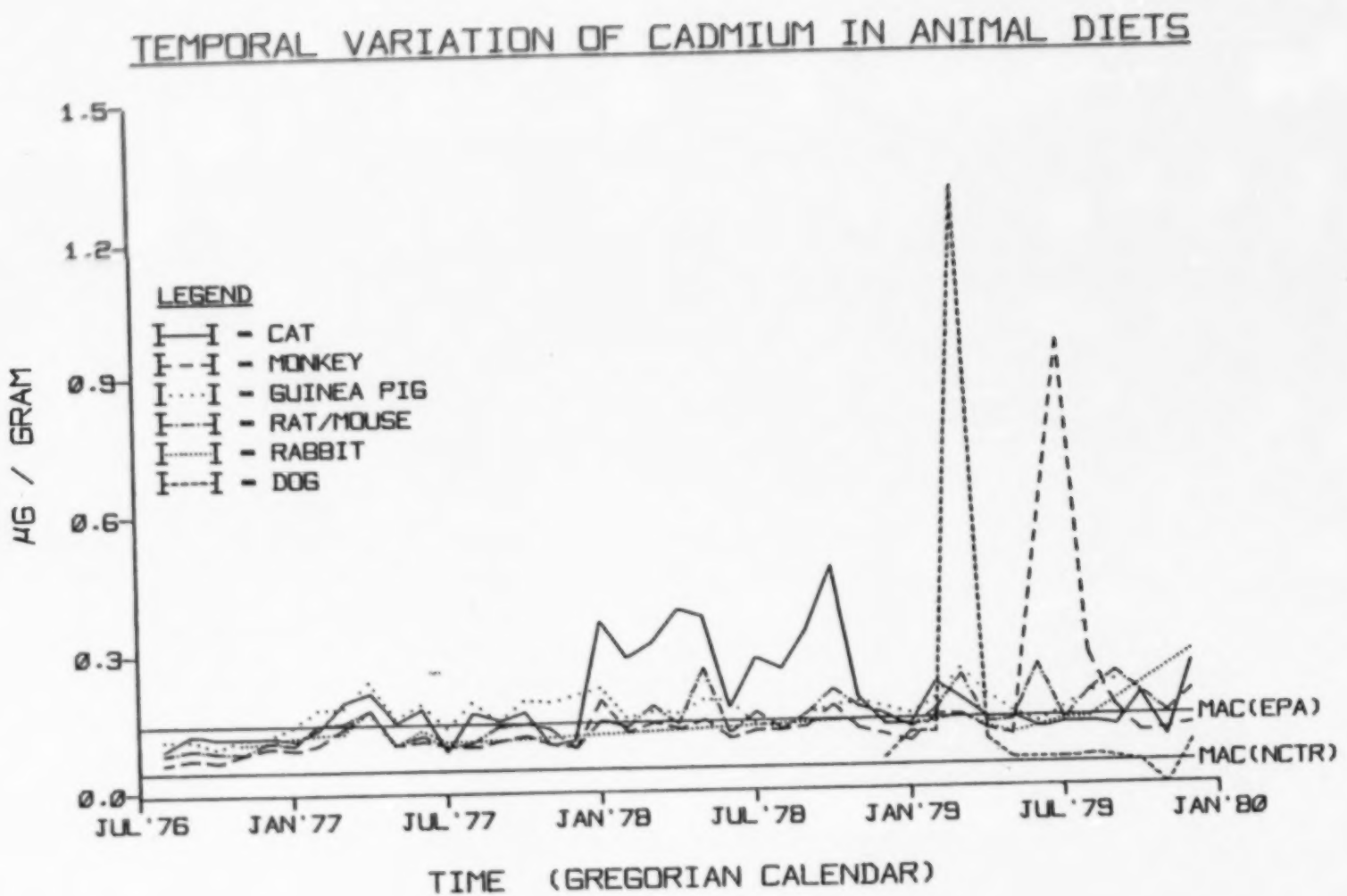
TEMPORAL VARIATION OF CADMIUM IN ANIMAL DIETS
1.5
1.2
0.9
0.6
0.3
0.0
MG / GRAM
LEGEND
- CAT
- MONKEY
- GUINEA PIG
- RAT/MOUSE
- RABBIT
- DOG
MAC(EPA)
MAC(NCTR)
JUL'76
JAN'77
JUL'77
JAN'78
JUL'78
JAN'79
JUL'79
JAN'80
TIME (GREGORIAN CALENDAR)

Table A-17. Lead (mcg/g)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	1.040	.1900	.3800	.4200	-	-
76/09	.6300	.1200	.7300	.2600	-	-
76/10	1.380	.2100	.3700	.3400	-	-
76/11	.6523	.1834	.4077	.4892	.5096	-
76/12	.5104	.1250	.5104	.4062	.5000	-
77/01	.8906	.0625	.3125	.3359	1.398	-
77/02	.3238	.0952	.2571	1.600	.3333	-
77/03	1.913	.1358	.4320	.3086	.7037	-
77/04	1.795	.1519	.8287	.6077	.7320	-
77/05	1.378	.1097	.4390	.3414	.4146	-
77/06	1.285	.0816	.4897	.5204	.5204	-
77/07	.4583	.1250	.5208	.4791	.3958	-
77/08	2.293	.1006	.3803	.3467	-	-
77/09	1.432	.2432	.6081	.4864	-	-
77/10	.7184	.0970	.8058	.3495	-	-
77/11	.2054	.2054	.9589	.8013	-	-
77/12	.9875	.9125	-	.5625	-	-
78/01	.6461	.1483	.6567	.5084	-	-
78/02	.7274	.1847	.5080	1.039	-	-
78/03	.9010	.1098	.3296	.3956	-	-
78/04	1.450	.1568	.3137	.3235	-	-
78/05	2.159	.2318	.4782	.4637	-	-
78/06	1.276	.4680	.5744	.6382	-	-
78/07	1.358	.6666	.5679	.6419	-	-
78/08	1.687	.6905	.6138	.5370	-	-
78/09	.8651	.6292	.9213	.6741	-	-
78/10	5.818	2.477	1.340	2.590	-	-
78/11	1.714	.6535	.4892	.5428	-	-
78/12	2.021	-	-	.5934	.5494	1.340
79/01	.3605	.6394	.5769	.4086	.5528	1.471
79/02	.6437	.1937	.3875	.6875	-	.9000
79/03	.7556	1.113	.8465	.4545	.5795	.9034
79/04	.5104	.1197	.3697	.9427	.6145	1.166
79/05	.6542	.7074	.3297	.3351	.4361	1.627
79/06	.5144	-	.3605	.4519	-	-
79/07	.7153	.5384	.9153	.6307	.8230	1.876
79/08	.5471	.2641	-	.5000	.4433	.6037
79/09	.6250	.4210	.7565	.5526	-	-
79/10	.7886	.2835	-	-	-	.7628
79/11	.6369	-	-	.4107	-	.6190
79/12	.8333	.2307	-	.4166	.7307	.9551
No.Obs.	41.00	38.00	35.00	40.00	17.00	11.00
Mean	1.124	.3704	.5647	.5848	.6021	1.111
Median	.7886	.1937	.4897	.4864	.5204	.9034
S.D.M.	.9229	.4377	.2380	.4037	.2450	.4208
S.E.E.	-	.4061	-	-	-	-
C.V.	82.07	118.1	42.14	69.02	40.69	37.86
Slope	-	.0139	-	-	-	-
Y-Intercept	-	.0926	-	-	-	-
Coeff.Det.(r^2)	-	.1392	-	-	-	-
t (.01)	( )	2.41 (1.64)	( )	( )	( )	( )
Range	.205 5.81	.062 2.47	.257 1.34	.260 2.59	.333 1.39	.603 1.87

Figure A-17.

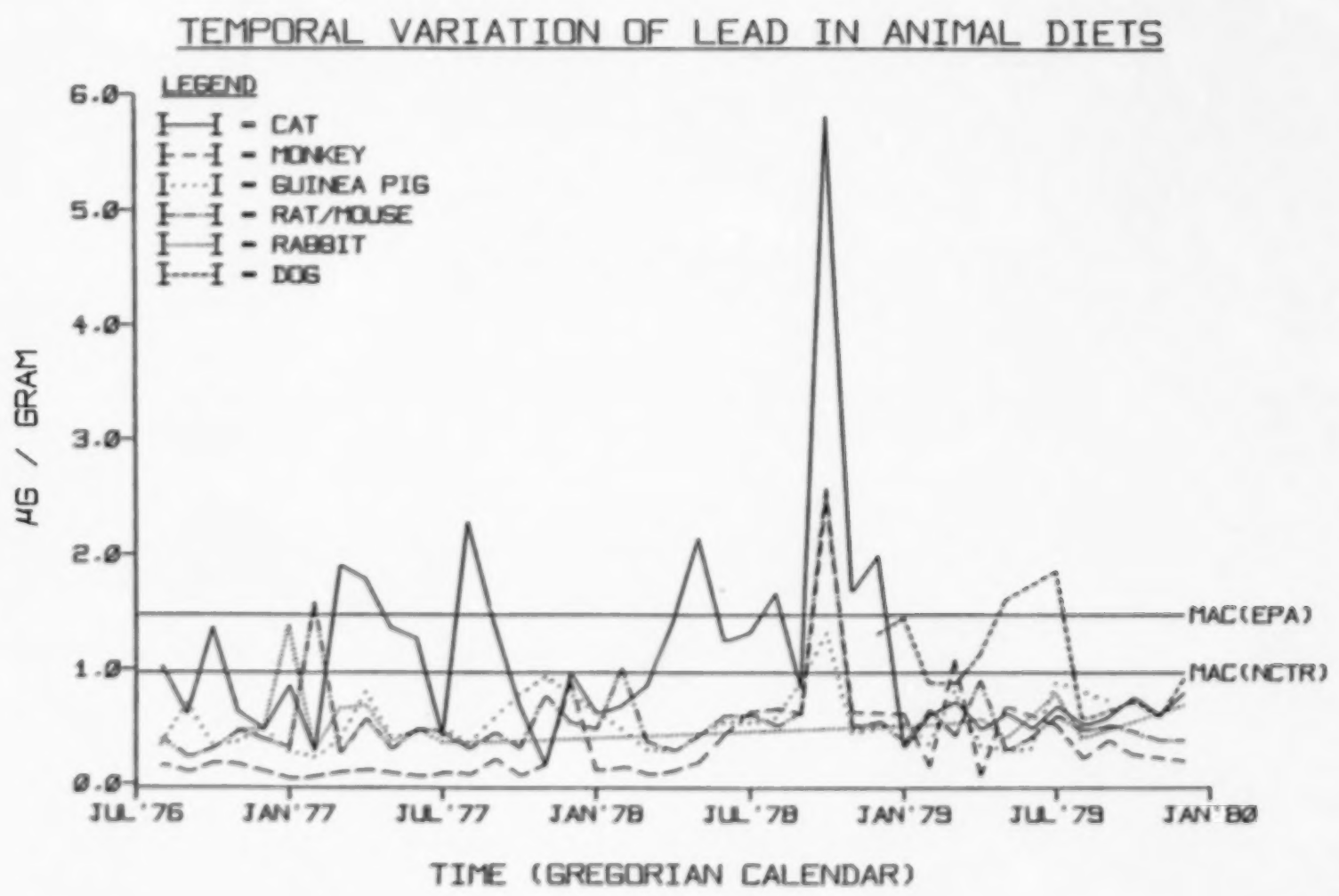
TEMPORAL VARIATION OF LEAD IN ANIMAL DIETS
LEGEND
I—I - CAT
I--I - MONKEY
I····I - GUINEA PIG
I-·-I - RAT/MOUSE
I—I - RABBIT
I---I - DOG
6.0
5.0
4.0
3.0
2.0
1.0
0.0
MG / GRAM
MAC(EPA)
MAC(NCTR)
JUL'76
JAN'77
JUL'77
JAN'78
JUL'78
JAN'79
JUL'79
JAN'80
TIME (GREGORIAN CALENDAR)

Table A-18. Selenium (mcg/g)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	.3200	.0800	.2400	.3800	-	-
76/09	.3700	.0900	.2000	.2500	-	-
76/10	.3100	.1100	.1800	.3900	-	-
76/11	.2956	.0844	.2745	.2534	.3379	-
76/12	.4366	.6259	.3202	.6404	.5967	-
77/01	.2609	.1186	.4270	.5456	.4982	-
77/02	.5316	.0862	.2729	.3017	.3591	-
77/03	.2476	.0380	.1904	.2380	.2857	-
77/04	.2524	.0679	.3883	.3592	.3300	-
77/05	.4326	.0801	.3525	.5929	.4487	-
77/06	.3393	.1018	.2828	.3846	.3506	-
77/07	.1962	.0654	.4362	.3598	.2617	-
77/08	.4593	.1181	.4855	.6692	-	-
77/09	.5169	.1329	.2363	.3988	-	-
77/10	.2736	.0631	.2105	.3789	-	-
77/11	.3133	.1907	.2861	.5177	-	-
77/12	.4103	.1519	-	.5167	-	-
78/01	.2510	.1046	.2615	.3138	-	-
78/02	.1800	.0700	.1800	.2600	-	-
78/03	.2877	.1251	.2752	.3503	-	-
78/04	.3353	.1448	.1600	.3506	-	-
78/05	.1548	.0968	.1064	.2710	-	-
78/06	.4988	.1160	.2204	.3248	-	-
78/07	.2272	.1250	.1363	.3181	-	-
78/08	.3015	.1256	.2512	.3768	-	-
78/09	.2886	.0923	.1847	.3464	-	-
78/10	.5399	.1479	.3180	.6139	-	-
78/11	.2028	.0849	.1650	.3915	-	-
78/12	.2087	-	-	.2912	.1373	.0549
79/01	.3395	.2160	.1913	.3086	.2901	.2160
79/02	.6736	.6631	.6210	.6052	-	.5473
79/03	.9615	1.057	.8974	1.044	.8525	.9423
79/04	.5285	.5857	.5714	.5809	.8476	.4476
79/05	.8141	.5973	.6814	.3451	.6769	.7610
79/06	.5663	-	.6283	.6150	-	-
79/07	.7142	.6581	.5459	.5714	.6326	.6377
79/08	.2242	.0841	-	.2710	.2663	.0747
79/09	.3827	.2407	.2222	.3950	-	-
79/10	.2626	.1594	-	-	-	.0938
.= 79/11	.2458	-	-	.2708	-	.0666
79/12	.2545	.1476	-	.2800	.1731	.1832
No.Obs.	41.00	38.00	35.00	40.00	17.00	11.00
Mean	.3758	.2065	.3257	.4168	.4320	.3659
Median	.3100	.1181	.2615	.3598	.3379	.1832
S.D.M.	.1788	.2291	.1812	.1630	.2186	.3166
S.E.E.	.1743	.2098	.1674	.1621	.2150	.2984
C.V.	47.59	110.9	55.64	39.11	50.59	86.54
Slope	.0033	.0078	.0062	.0014	.0026	-.029
Y-Intercept	.3054	.0501	.2077	.3868	.3744	1.251
Coeff.Det.(r^2)	.0503	.1609	.1462	.0111	.0320	.1115
t (.01)	3.02 (1.64)	3.02 (1.64)	3.02 (1.64)	3.02 (1.64)	3.02 (1.74)	3.02 (1.79)
Range	.154 .961	.038 1.05	.106 .897	.238 1.04	.137 .852	.054 .942

Figure A-18.

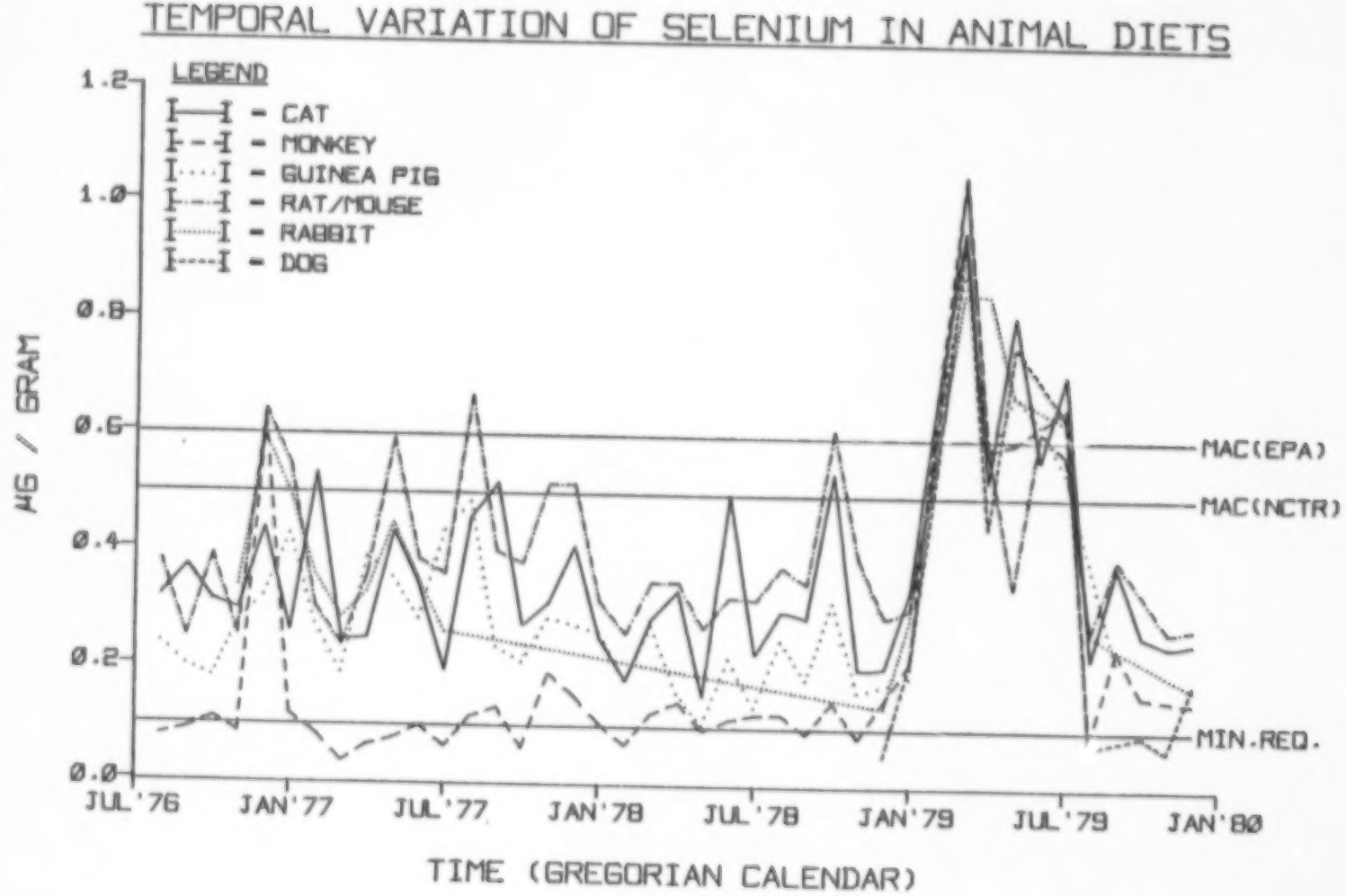
TEMPORAL VARIATION OF SELENIUM IN ANIMAL DIETS
LEGEND
CAT
MONKEY
GUINEA PIG
RAT/MOUSE
RABBIT
DOG
MG / GRAM
1.2
1.0
0.8
0.6
0.4
0.2
0.0
MAC(EPA)
MAC(NCTR)
MIN.REQ.
JUL'76
JAN'77
JUL'77
JAN'78
JUL'78
JAN'79
JUL'79
JAN'80
TIME (GREGORIAN CALENDAR)

Table A-19. Malathion (mcg/g)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	0	0	0	0	-	-
76/09	0	0	0	0	-	-
76/10	.0280	0	.0530	.0940	-	-
76/11	.0500	.0400	.1500	.0400	.0400	-
76/12	.0600	0	.0900	.0900	.0500	-
77/01	0	0	.0690	.0860	.0590	-
77/02	.0800	0	.0790	0	.0400	-
77/03	.0220	.0360	.4000	.0880	.0490	-
77/04	0	0	.0700	.0780	.0530	-
77/05	.0250	0	.3000	.1100	.0780	-
77/06	0	0	.3000	.1300	.0900	-
77/07	0	0	0	.0460	.0560	-
77/08	0	0	.0800	.0700	-	-
77/09	0	0	.0560	.1100	-	-
77/10	0	0	0	.1100	-	-
77/11	0	0	.1700	.1100	-	-
77/12	0	.4000	-	0	-	-
78/01	.1500	0	1.200	.1100	-	-
78/02	.1600	0	.0150	.0980	-	-
78/03	.1200	0	.1000	.0800	-	-
78/04	0	.1400	.1300	.1050	-	-
78/05	0	.1400	.2000	.3600	-	-
78/06	0	.1100	.6700	.1600	-	-
78/07	.1300	.2300	.1400	.1700	-	-
78/08	.1400	.2600	.2200	.1100	-	-
78/09	.1400	.1400	.1300	.0900	-	-
78/10	.1000	.1000	.1000	.1100	-	-
78/11	.2500	.0800	.1800	.1500	-	-
78/12	.0400	-	-	.0600	.0200	.0100
79/01	0	.0800	.0400	.1700	.2400	.0400
79/02	.9600	.1800	.1000	.0900	-	.0500
79/03	.2000	.1000	.1100	.2400	.1200	.0400
79/04	.1300	.2100	.1400	.2000	.0940	0
79/05	.1500	.1500	.2200	.1000	.1100	0
79/06	0	-	.4200	.0500	-	-
79/07	.2800	.1800	.1900	.1400	.2800	.1800
79/08	0	.2000	-	.1700	.1800	0
79/09	0	.2700	0	.2000	-	-
79/10	.0800	.1500	-	-	-	.1300
79/11	0	-	-	.1200	-	.0800
79/12	0	.1600	-	.1200	0	0
No.Obs.	41.00	38.00	35.00	40.00	17.00	11.00
Mean	.0803	.0883	.1749	.1091	.0917	.0481
Median	0	.0400	.1000	.1050	.0560	.0100
S.D.M.	.1603	.1017	.2265	.0682	.0761	.0599
S.E.E.	.1545	.0760	-	.0595	.0669	-
C.V.	199.4	115.2	129.4	62.56	83.08	124.4
Slope	.0035	.0057	-	.0028	.0026	-
Y-Intercept	.0057	-.026	-	.0507	.0382	-
Coeff.Det.(r^2)	.0704	.4416	-	.2397	.2279	-
t (.01)	1.71 (1.64)	5.32 (1.64)	( )	3.45 (1.64)	2.09 (1.74)	( )
Range	0 .960	0 .400	0 1.20	0 .360	0 .280	0 .180

Figure A-19.

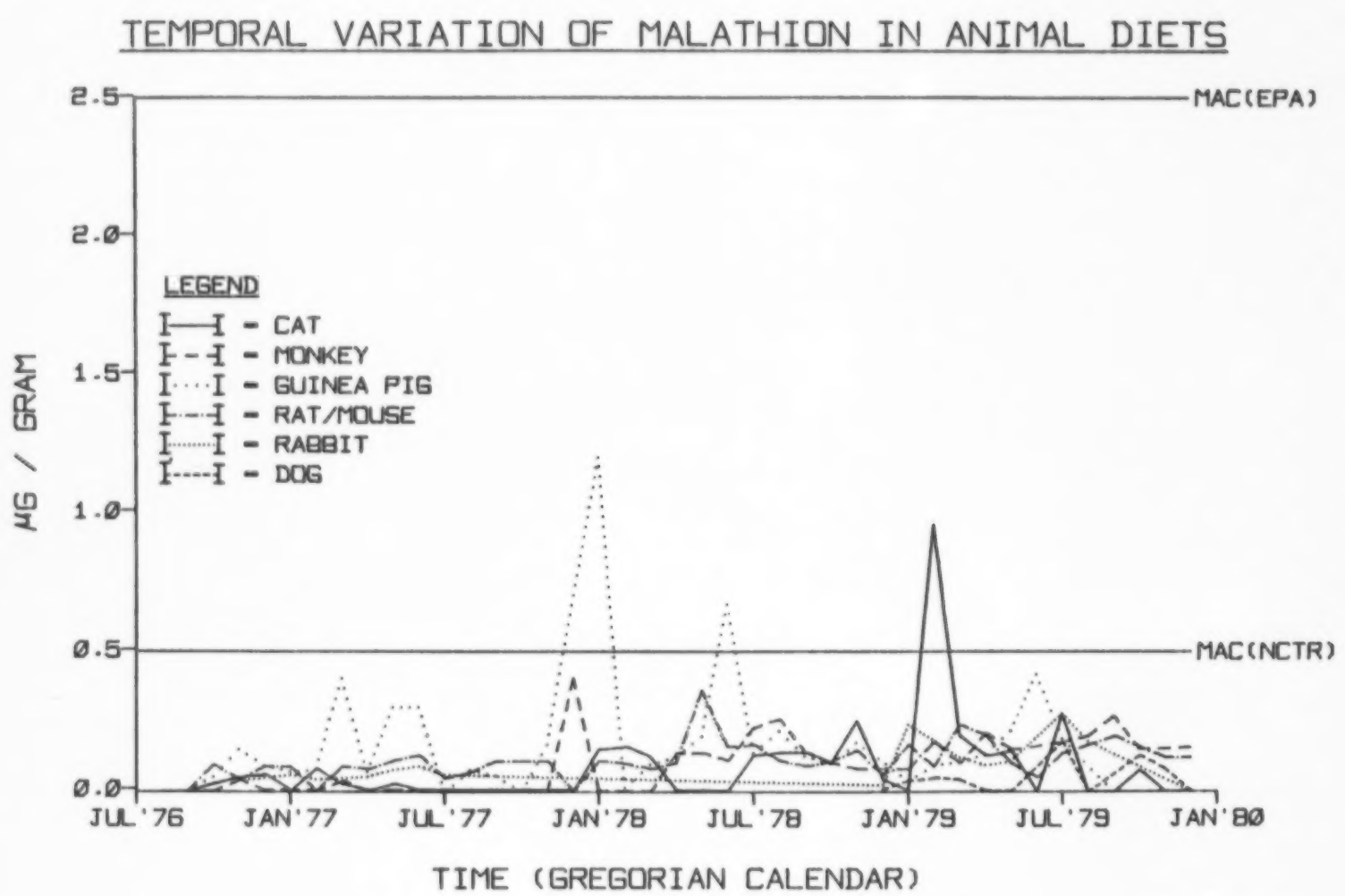
TEMPORAL VARIATION OF MALATHION IN ANIMAL DIETS
MAC(EPA)
MAC(NCTR)
LEGEND
CAT
MONKEY
GUINEA PIG
RAT/MOUSE
RABBIT
DOG
MG / GRAM
2.5
2.0
1.5
1.0
0.5
0.0
JUL'76
JAN'77
JUL'77
JAN'78
JUL'78
JAN'79
JUL'79
JAN'80
TIME (GREGORIAN CALENDAR)

Table A-20. PCBs (ng/g)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	-	-	-	-	-	-
76/09	0	0	0	0	-	-
76/10	0	0	11.00	39.00	-	-
76/11	0	0	0	0	0	-
76/12	11.00	0	0	54.00	0	-
77/01	0	0	0	77.00	0	-
77/02	37.00	0	0	0	0	-
77/03	0	0	0	16.00	0	-
77/04	12.00	0	11.00	17.00	10.00	-
77/05	0	0	0	28.00	0	-
77/06	0	0	0	0	0	-
77/07	0	0	0	42.00	0	-
77/08	0	0	13.00	20.00	-	-
77/09	0	20.00	31.00	48.00	-	-
77/10	43.00	0	23.00	45.00	-	-
77/11	54.00	0	0	41.00	-	-
77/12	57.00	0	-	22.00	-	-
78/01	0	0	0	25.00	-	-
78/02	0	0	0	40.00	-	-
78/03	10.00	11.00	13.00	185.0	-	-
78/04	0	0	0	17.00	-	-
78/05	0	0	0	0	-	-
78/06	0	0	20.00	0	-	-
78/07	0	0	0	0	-	-
78/08	0	36.00	0	0	-	-
78/09	10.00	0	12.00	16.00	-	-
78/10	0	0	0	0	-	-
78/11	0	0	0	0	-	-
78/12	0	-	-	0	0	0
79/01	0	0	0	0	0	0
79/02	0	0	0	0	-	0
79/03	14.00	14.00	14.00	19.00	13.00	0
79/04	11.00	0	0	0	15.00	0
79/05	0	0	-	0	0	0
79/06	0	-	0	0	-	-
79/07	0	0	0	0	0	0
79/08	0	0	-	0	0	0
79/09	11.00	12.00	0	14.00	-	-
79/10	0	0	-	-	-	0
79/11	0	-	-	0	-	0
79/12	0	0	-	0	0	0
No.Obs.	40.00	37.00	33.00	39.00	17.00	11.00
Mean	6.750	2.513	4.484	19.61	2.235	0
Median	0	0	0	0	0	0
S.D.M.	14.73	7.309	8.189	33.59	5.056	0
S.E.E.	-	-	-	31.80	-	-
C.V.	218.2	290.7	182.6	171.2	226.2	-
Slope	-	-	-	-.943	-	-
Y-Intercept	-	-	-	39.46	-	-
Coeff.Det.(r^2)	-	-	-	.1039	-	-
t (.01)	( )	( )	( )	2.06 (1.64)	( )	( )
Range	0 57.0	0 36.0	0 31.0	0 185.	0 15.0	0 0

Figure A-20.

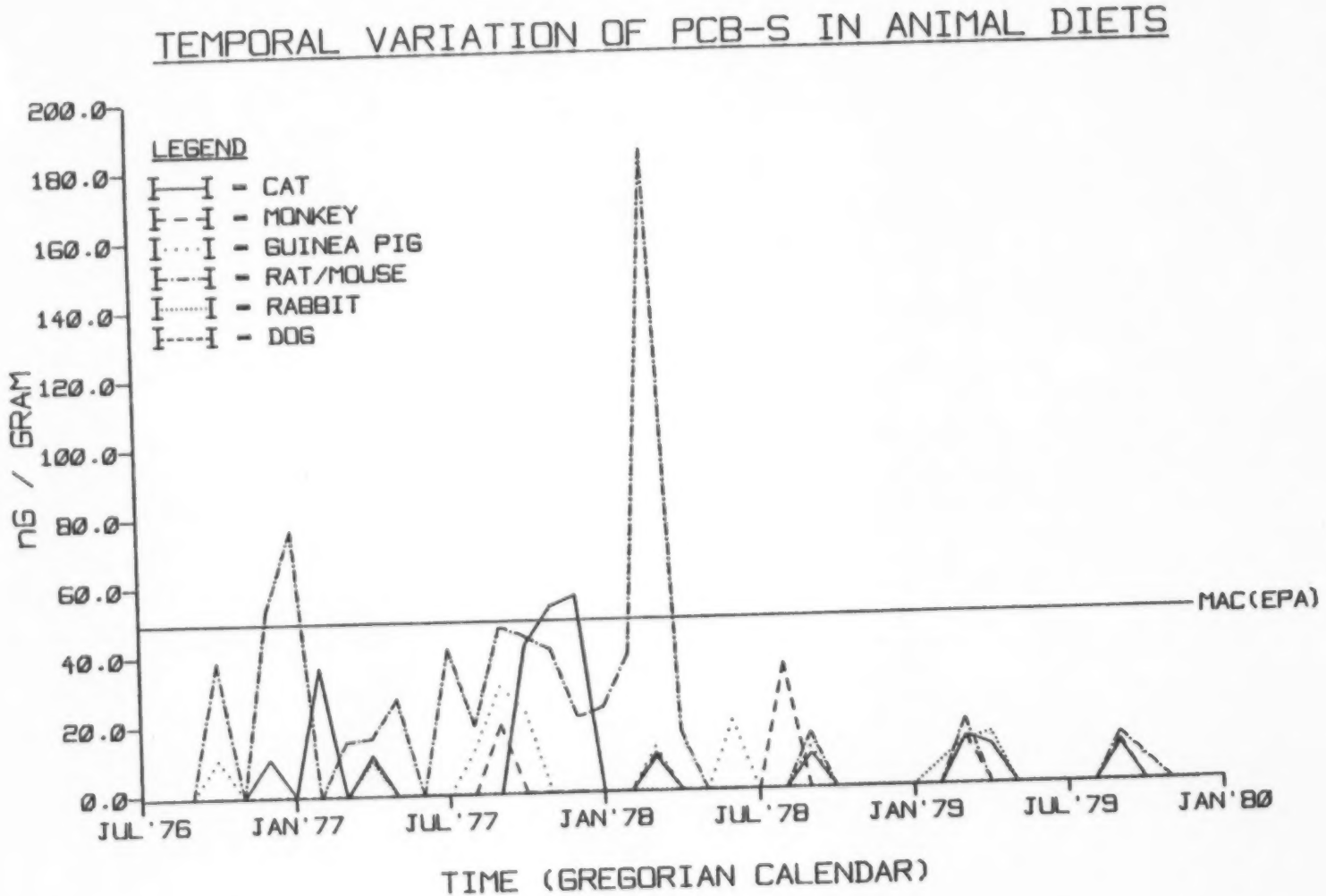
TEMPORAL VARIATION OF PCB-S IN ANIMAL DIETS
LEGEND
I—I - CAT
I- -I - MONKEY
I···I - GUINEA PIG
I-·-I - RAT/MOUSE
I·····I - RABBIT
I----I - DOG
NG / GRAM
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
MAC(EPA)
JUL'76
JAN'77
JUL'77
JAN'78
JUL'78
JAN'79
JUL'79
JAN'80
TIME (GREGORIAN CALENDAR)

Table A-21. DDTs (ng/g)

Date(YY/MM)	Cat	Monkey	G.Pig	Rodent	Rabbit	Dog
76/08	-	-	-	-	-	-
76/09	0	0	0	0	-	-
76/10	0	0	14.00	38.00	-	-
76/11	0	0	0	19.00	0	-
76/12	12.00	0	0	12.00	0	-
77/01	0	0	0	51.00	0	-
77/02	25.00	0	0	0	0	-
77/03	0	0	0	0	0	-
77/04	0	0	0	0	0	-
77/05	0	0	0	9.000	0	-
77/06	0	0	0	0	0	-
77/07	0	0	0	42.00	0	-
77/08	0	0	0	6.000	-	-
77/09	0	0	0	6.000	-	-
77/10	26.00	8.000	8.000	16.00	-	-
77/11	26.00	0	0	8.000	-	-
77/12	19.00	0	-	13.00	-	-
78/01	6.000	0	0	30.00	-	-
78/02	0	0	0	36.00	-	-
78/03	0	0	0	0	-	-
78/04	0	0	0	0	-	-
78/05	0	0	0	84.00	-	-
78/06	0	0	24.00	69.00	-	-
78/07	0	0	0	0	-	-
78/08	0	0	0	0	-	-
78/09	0	0	0	0	-	-
78/10	0	0	0	0	-	-
78/11	0	0	0	14.00	-	-
78/12	0	-	-	0	0	0
79/01	0	0	47.00	0	0	0
79/02	0	0	0	0	-	0
79/03	0	0	0	0	0	0
79/04	0	0	0	0	6.000	0
79/05	0	0	0	62.00	0	0
79/06	0	-	0	0	-	-
79/07	0	0	0	0	0	0
79/08	0	0	-	21.00	0	0
79/09	0	0	0	0	-	-
79/10	10.00	0	-	-	-	0
79/11	0	-	-	0	-	0
79/12	0	0	-	0	0	0
No.Obs.	40.00	37.00	34.00	39.00	17.00	11.00
Mean	3.100	.2162	2.735	13.74	.3529	0
Median	0	0	0	0	0	0
S.D.M.	7.567	1.315	9.195	21.81	1.455	0
S.E.E.	-	-	-	-	-	-
C.V.	244.1	608.2	336.1	158.7	412.3	-
Slope	-	-	-	-	-	-
Y-Intercept	-	-	-	-	-	-
Coeff.Det.(r^2)	-	-	-	-	-	-
t (.01)	( )	( )	( )	( )	( )	( )
Range	0 26.0	0 8.00	0 47.0	0 84.0	0 6.00	0 0

Figure A-21.

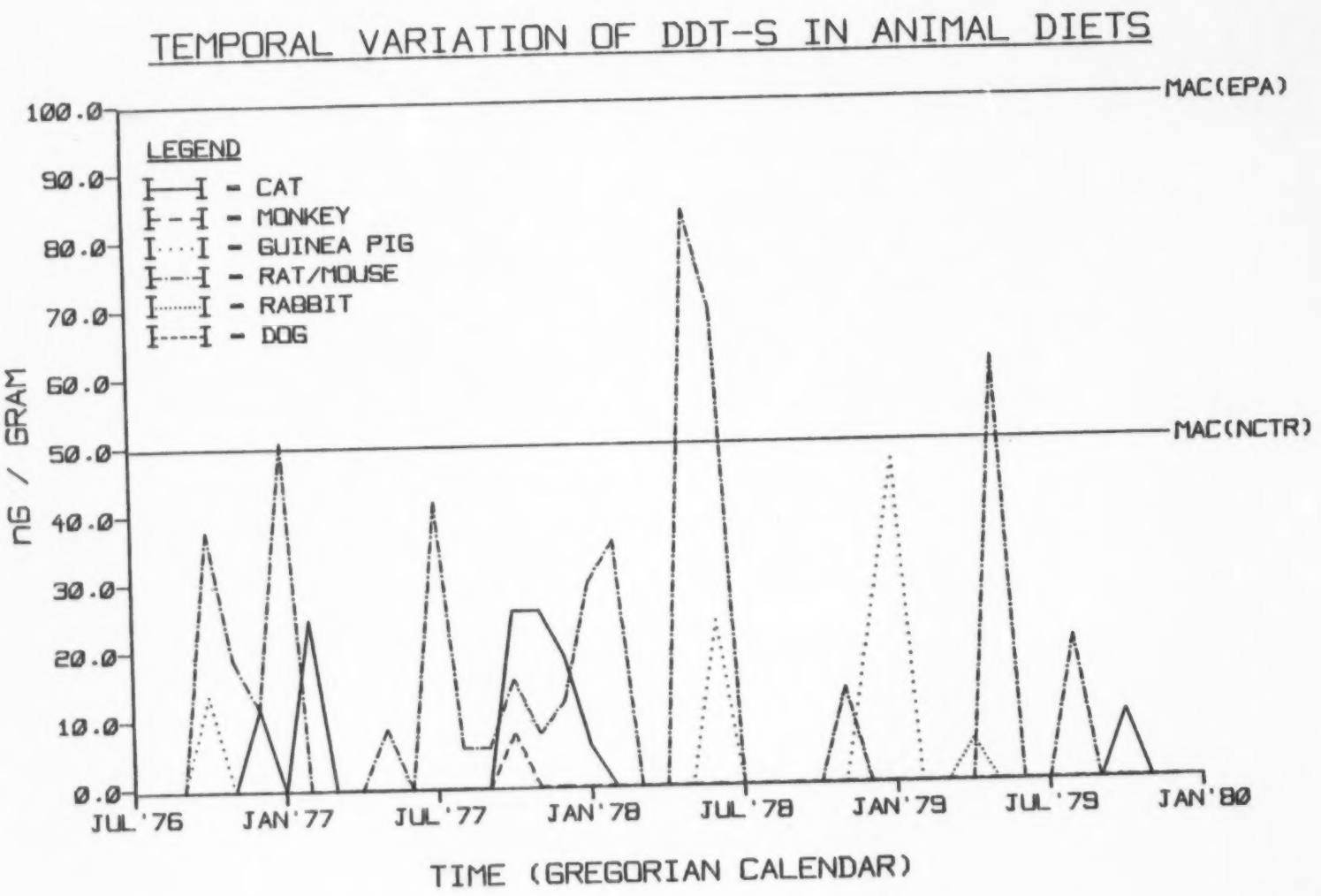
TEMPORAL VARIATION OF DDT-S IN ANIMAL DIETS
MAC(EPA)
MAC(NCTR)
LEGEND
I—I - CAT
I--I - MONKEY
I····I - GUINEA PIG
I-·-I - RAT/MOUSE
I·····I - RABBIT
I----I - DOG
NG / GRAM
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
JUL '76
JAN '77
JUL '77
JAN '78
JUL '78
JAN '79
JUL '79
JAN '80
TIME (GREGORIAN CALENDAR)

Table A-22. Precision of Recoveries.(%)

Date(YY/MM)	Mn	As	Cd	Pb	Hg	Se
76/08	-	-	-	-	-	-
76/09	-	-	-	-	-	-
76/10	-	-	-	-	-	-
76/11	94.30	92.00	90.00	98.10	90.00	94.70
76/12	98.40	93.00	88.00	96.00	90.00	68.70
77/01	96.20	90.00	95.00	128.0	50.00	84.30
77/02	98.30	106.0	92.00	105.0	95.00	69.60
77/03	99.00	102.0	90.00	81.00	100.0	105.0
77/04	95.00	94.00	82.50	72.40	90.00	103.0
77/05	92.00	107.0	104.0	82.00	100.0	62.40
77/06	96.70	98.00	87.30	98.00	87.00	88.40
77/07	100.0	82.50	98.50	96.00	95.00	91.70
77/08	98.99	83.00	81.00	89.40	115.0	76.20
77/09	98.40	98.00	96.50	74.00	85.00	67.70
77/10	96.00	94.00	80.00	103.0	84.20	95.00
77/11	95.40	91.00	87.50	146.0	115.0	73.40
77/12	101.0	84.00	105.0	80.00	85.00	65.80
78/01	92.60	97.00	70.80	94.40	101.0	95.60
78/02	98.60	85.00	94.00	86.60	110.0	100.0
78/03	96.80	85.00	81.00	91.00	104.0	79.92
78/04	93.40	82.00	87.00	102.0	90.00	65.60
78/05	95.60	92.00	91.00	69.00	99.00	103.3
78/06	94.00	85.00	89.00	94.00	80.50	86.20
78/07	99.30	86.00	77.00	81.00	97.50	88.00
78/08	101.0	92.00	76.60	78.20	71.00	79.60
78/09	102.0	85.00	72.60	89.00	85.00	86.60
78/10	97.00	84.00	72.00	88.00	91.50	67.60
78/11	95.00	100.0	74.00	140.0	126.0	106.0
78/12	102.0	83.00	98.00	91.00	103.0	91.00
79/01	97.90	79.00	100.0	104.0	93.00	81.00
79/02	99.50	100.0	88.00	80.00	96.00	95.00
79/03	103.0	80.00	79.00	88.00	72.00	78.00
79/04	99.30	88.00	98.00	96.00	99.50	105.0
79/05	99.70	74.00	99.80	94.00	89.00	113.0
79/06	98.40	78.80	95.00	104.0	110.0	113.0
79/07	99.50	85.50	83.00	65.00	140.0	98.00
79/08	102.0	87.50	88.00	106.0	121.0	107.0
79/09	-	80.00	82.00	76.00	108.0	81.00
79/10	-	90.00	101.0	97.00	106.0	106.6
79/11	-	82.50	87.00	84.00	85.00	120.0
79/12	-	96.00	90.40	78.00	102.5	98.20
No.Obs.	34.00	38.00	38.00	38.00	38.00	38.00
Mean	97.83	89.25	88.19	92.76	96.36	89.24
Median	98.40	87.50	88.00	91.00	95.00	88.40
S.D.M.	2.837	7.936	9.190	17.17	16.05	15.37
S.E.E.	2.550	7.003	-	-	15.19	13.72
C.V.	2.900	8.891	10.41	18.51	16.65	17.23
Slope	.1247	-.335	-	-	.4665	.6247
Y-Intercept	95.27	96.81	-	-	85.86	75.18
Coeff.Det.(r^2)	.1918	.2212	-	-	.1042	.2038
t (.01)	2.74 (1.64)	3.19 (1.64)	( )	( )	2.04 (1.64)	3.02 (1.64)
Range	92.0 103.	74.0 107.	70.8 105.	65.0 146.	50.0 140.	62.4 120.